



**US Army Corps
of Engineers®**



UNIFIED FACILITIES CRITERIA (UFC)

DESIGN STANDARDS FOR VISUAL AIR NAVIGATION FACILITIES

U.S. ARMY CORPS OF ENGINEERS

NAVAL FACILITIES ENGINEERING COMMAND

AIR FORCE CIVIL ENGINEER SUPPORT AGENCY

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SECRETARY OF THE AIR FORCE**

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DESIGN STANDARDS FOR VISUAL AIR NAVIGATION FACILITIES

COMPLIANCE WITH THIS PUBLICATION IS MANDATORY

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(Col Bruce R. Barthold)

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This document provides the guidance and detailed information on standard configurations and equipment to comply with the complementary AFI 32-[1044](#), *Visual Air Navigation Systems*. Use it when designing, planning, constructing, and installing new systems. This document applies to Air National Guard and Air Force Reserve bases with responsibility for maintaining their airfield facilities. Existing systems are not required to be upgraded to these standards unless as part of a major rehabilitation. Navy requirements are currently contained in NAVAIR 51-50-AAA-2, *General Requirements for Shorebased Airfield Marking and Lighting*. When using this document, be certain that the complementary markings are installed and that no conflict occurs with the placement of light fixtures. Send comments and suggested improvements on AF Form 847, **Recommendation for Change of Publication**, through major commands to HQ AFCESA/CESM, 139 Barnes Drive, Suite 1, Tyndall AFB FL 32403-5319, or HQ USAF/ILE, 1260 Pentagon, Washington DC 20330-1260.

SUMMARY OF REVISIONS

This revision creates a new document from AFJMAN 32-1076, 1 December 1997, and Army TM5-811-5, 13 December 1991. It no longer authorizes the installation of VASI or PLASI systems, but permits continued use at some existing facilities. It realigns lighting for temporary displaced thresholds with FAA guidance (paragraph 4.5.3); expands lighting for helipads (Chapter 7); adds hospital helipad lighting and a glide slope indicator (CHAPI) for helipads (paragraph 7.6); expands photometric curves and criteria in each applicable section (Chapters 3, 4, and 15); adds figures of typical FAA equipment used in most systems with cross-reference to the application section where they are used (Chapter 13); adds compliance checks for applicability to NATO STANAGs and ASCC Air Standards for each system (Chapters 3 through 11); adds an air facility equipment inspection and testing chapter containing guidelines and checklists for testing and inspection of new systems prior to service (Chapter 14); and adds a chapter containing the characteristics of airfield ground lighting, including power, control, and monitoring (Chapter 15).

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PART 1 - STANDARDS

Chapter 1

INTRODUCTION TO STANDARDS AND CRITERIA

1.1. Purpose of Chapter. This chapter contains the configuration standards, application and installation criteria, and a listing of applicable specifications for all visual air navigation facilities, except marking, at Air Force and US Army facilities.

1.2. Background. The term “visual air navigation facilities” refers to all the lights, signs, symbols, and other visual aid devices located on and in the vicinity of an airfield. These facilities provide a visual reference and guidance to pilots when operating aircraft on the ground and in the air. These facilities also supplement the guidance provided by electronic aids such as Tactical Air Navigation (TACAN), Precision Approach Radar (PAR), and Instrument Landing System (ILS), for operating aircraft. Markings are covered in AFI 32-1042, *Standards for Marking Airfields*.

1.2.1. Visual facilities must be standardized for operational safety. Standardization means the configuration and color of the lights at each airfield are identical and have the same meaning. Standardization enables pilots to readily interpret the guidance information in an intuitive manner.

1.2.2. According to Public Law 85-726, the Federal Aviation Administration (FAA) regulates and promotes civil aviation to best foster its development and safety, and to provide for the safe and efficient use of the airspace by both civil and military aircraft. The FAA develops, modifies, tests, and evaluates systems, procedures, facilities, and devices. It also defines the performance characteristics needed for safe and efficient navigation and traffic control of all civil and military aviation.

1.3. Application. Use this document for all major rehabilitation (i.e., when over half of the lighting system requires replacement), or for the establishment of new visual air navigation facilities at Air Force and US Army installations. Do not install visual air navigation facilities or equipment, other than those covered in this publication, except when an appropriate waiver has been obtained (refer to paragraph 1.8 for Air Force waivers, or paragraph 1.9 for US Army waivers). Exceptions are:

1.3.1. Where international military standards apply (paragraph 1.5).

1.3.2. Where Base Rights Agreements apply (paragraph 1.6).

1.3.3. Where existing facilities configured to prior standards and criteria continue to give satisfactory service (paragraph 1.12).

1.4. FAA Standards. The Air Force generally follows FAA standards which are primarily published as advisory circulars, handbooks, and specifications. However, when they are in conflict with the Air Force or US Army requirements, this document takes precedence.

1.5. International Military Standards:

1.5.1. This document satisfies the requirements of international military standards whenever possible.

1.5.1.1. North Atlantic Treaty Organization (NATO) Standardization Agreements (STANAGs) are promulgated by the NATO Military Agency for Standardization (MAS).

1.5.1.2. Air Standardization Coordinating Committee (ASCC) Air Standards (AIR STDs) are promulgated by representatives of the military air forces of the United States, Canada, Australia, New Zealand, and the United Kingdom.

1.5.2. The applicable international military standards, available at the web site <https://www.imswms.hq.af.mil/>, take precedence over the Air Force standards in this document as follows:

1.5.2.1. NATO: At Air Force facilities in NATO theater countries except the United States and Canada, or wherever NATO funding is provided for the work, regardless of location.

1.5.2.2. ASCC: At Air Force facilities in New Zealand and Australia.

Information on obtaining copies of these standards can be obtained by contacting: HQ USAF/XORD-ISO, 1815 North Fort Myer Drive, Suite 400, Arlington VA 2209-1809, DSN 426-8422/8436/8445, or commercial (703) 696-8422/8436/8445.

1.6. Base Rights Agreements. When the Air Force constructs an airfield in a foreign country, the United States obtains a Base Rights Agreement. This is an agreement of the foreign states, but not by the Air Force. The provisions of the particular Base Rights Agreement must be observed and they may require that the construction be done according to the standards of the host country. Under such an agreement, and regardless of the conformity of the international standards with the standards of the host country, the host country must approve all plans. It may also be desirable to use equipment produced in the host country.

1.7. Visual and Electronic Aids. Provide visual air navigation aids appropriate for operational requirements and associated electronic aids. See table 2.1A, Visual Facilities AIR FORCE Airfield Requirements Matrix or table 2.1B, Visual Facilities US ARMY Airfield Requirements Matrix. Except for Visual Flight Rules (VFR) operation, electronic aids are needed to provide initial positioning and direction information to an approaching aircraft. Visual landing aids ensure a timely and safe transition from the instrument phase to the visual phase of an approach. Failure to provide the necessary visual aids on an instrument runway will degrade the utility of the electronic systems. Furthermore, enhancing a runway with unnecessary visual aids wastes resources and offers minimal operational advantages. Do not upgrade visual aids for a higher level of operations unless the runway, taxiway, or helipad is approved for that level, and appropriate electronic aids are programmed for installation. Waivers are required for all deviations. See complementary information in paragraph 2.3.

1.8. Air Force Waivers of Requirement. The major command (MAJCOM) may waive requirements of this document if compliance is not practical or feasible. In exercising this waiver authority, the MAJCOM must not adversely impact the effectiveness or safety of operations for any aircraft which may use the airfield. Funding or budgetary constraints normally are not adequate justification for granting a waiver. Each MAJCOM must establish and document procedures for processing waivers. They may use existing documented procedures:

1.8.1. The MAJCOM/CE has waiver authority which must not be redelegated.

1.8.2. Coordinate all waiver requests with the Airfield Management and Flying Safety Offices at the base, wing, and MAJCOM level. In accordance with AFI 13-213, *Airfield Management*, offices must coordinate as necessary with local flying units and the air traffic control agencies (FAA) providing Terminal Instrument Procedures services for the affected locations.

1.8.3. Coordinate with the FAA on waiver requests involving facilities at joint-use airfields as they are subject to the provisions of Federal Aviation Regulation (FAR) Part 77, *Objects Affecting Navigable Airspace*, and FAR Part 139, *Certification and Operations: Land Airports Serving Certain Air Carriers*.

1.8.4. Document approved waivers and make them a part of the permanent facility records, available for examination during inspections.

1.8.5. Forward copies of the complete documentation, including detailed justification, of each approved waiver to:

HQ AFCESA/CESM	139 Barnes Drive, Suite 1 Tyndall AFB FL 32403-5319
AFCEE/DGP	3207 North Road Brooks AFB TX 78235-5364
HQ USAF/XOOA	1480 Air Force Pentagon, Wash DC 20330-1480
HQ AFSC/SEFF	9700 G Avenue, South East Kirtland AFB NM 87117-5367
HQ AFFSA/XA	1535 Command Drive, Suite D302 Andrews AFB MD 20762-7002
HQ AFFSA/XOI	1535 Command Drive, Suite D305 Andrews AFB MD 20762-7002

1.8.6. A waiver is not required where existing facilities meet prior standards and continue to give satisfactory service.

1.9. US Army Waiver Processing Procedures:

1.9.1. Waiver Procedures:

1.9.1.1. Installation. The installation's design agent, aviation representative (safety officer, operations officer, and/or Air Traffic and Airspace (AT&A) officer) and installation master planner will:

1.9.1.1.1. Jointly prepare/initiate waiver requests.

1.9.1.1.2. Submit requests through the installation to the Major Command (MACOM).

1.9.1.1.3. Maintain a complete record of all waivers requested and their disposition (approved or disapproved). A list of waivers to be requested and those approved for a project should also be included in the project design analysis prepared by the design agent aviation representative, or installation master planner.

1.9.1.2. The MACOM will:

1.9.1.2.1. Ensure that all required coordination has been accomplished.

1.9.1.2.2. Ensure that the type of waiver requested is clearly identified as either "Temporary" or "Permanent." Permanent waivers are required when no further mitigative actions are intended or necessary. Temporary waivers are issued for a specified period during which additional actions to mitigate the situation must be

initiated to fully comply with criteria or to obtain a permanent waiver. Follow-up inspections will be necessary to ensure that mitigative actions proposed for each Temporary waiver granted have been accomplished.

1.9.1.2.3. Review waiver requests and forward all viable requests to US Army Aeronautical Service Agency (USAASA) for action. To expedite the waiver process, MACOMs are urged to simultaneously forward copies of the request to:

Director, US Army Aeronautical Services Agency (USAASA)

ATTN: MOAS-AI
9325 Gunston Road, Suite N319
Fort Belvoir, VA 22060-5582.

Commander, US Army Safety Center (USASC)

ATTN: CSSC-SPC
Bldg. 4905, 5th Ave.
Fort Rucker, AL 36362-5363.

Director, US Army Aviation Center (USAAVNC)

ATTN: ATZQ-ATC-AT
Fort Rucker, AL 36362-5265.

Director, USACE Transportation Systems Center (TSMCX)

ATTN: CEMRO-ED-TX
215 N. 17th St.
Omaha, NE 68102.

1.9.1.3. USAASA. USAASA is responsible for coordinating the following reviews for the waiver request:

1.9.1.3.1. Air traffic control assessment by USAAC.

1.9.1.3.2. Safety and risk assessment by USASC.

1.9.1.3.3. Technical engineering review by TSMCX.

From these reviews, USAASA formulates a consolidated position and makes the final determination on all waiver requests, and is responsible for all waiver actions for Army operational airfield/airspace criteria.

1.9.2. Contents of Waiver Requests. Each request must contain the following information:

1.9.2.1. Reference to the specific standard and/or criterion to be waived by publication, paragraph, and page.

1.9.2.2. Complete justification for noncompliance with the airfield/airspace criteria and/or design standards. Demonstrate that noncompliance will provide an acceptable level of safety, economics, durability and quality for meeting the Army mission. This would include reference to special studies made to support the decision.

1.9.2.1. Justification for Waivers. Specific justification for waivers to criteria and allowances must be included as follows:

1.9.2.1.1. When specific site conditions (physical and functional constraints) make compliance with existing criteria impractical and/or unsafe; for example: the need to provide hangar space for all aircraft because of recurring adverse weather conditions; the need to expand hangar space closer to and within the runway clearances due to lack of land; and the maintenance of fixed-wing Class A clearance when support of Class B fixed-wing aircraft operations are over 10% of the airfield operations.

1.9.2.1.2. When deviation(s) from criteria fall within a reasonable margin of safety and do not impair construction of long range facility requirements; for example, locating security fencing around and within established clearance areas.

1.9.2.1.3. When construction that does not conform to criteria is the only alternative to meet mission requirements. Evidence of analysis and efforts taken to follow criteria and standards must be documented and referenced.

1.9.2.2. Operational Factors. Include information on the following existing and/or proposed operational factors used in the assessment:

1.9.2.2.1. Mission urgency.

1.9.2.2.2. All aircraft by type and operational characteristics.

1.9.2.2.3. Density of aircraft operations at each air operational facility.

1.9.2.2.4. Facility capability (VFR or Instrument Flight Rules (IFR)).

1.9.2.2.5. Use of self-powered parking versus manual parking.

1.9.2.2.6. Safety of operations (risk management).

1.9.2.2.7. Existing navigational aids (NAVAIDS).

1.9.2.3. Documentation. Record all alternatives considered, their consequences, necessary mitigative efforts, and evidence of coordination.

1.10. Metrication of Dimensions. Use the International Civil Aviation Organization's (ICAO) standard English or metric equivalents rounded off (for example, 30 meters equals 100 feet), even though they do not represent exact conversions. No change in standard dimensions, tolerances, or performance specifications is needed if they are applied consistently. **NOTE:** Executive Order 12770, *Metric Usage in Federal Government Programs* (July 25, 1991), requires use of metric units in procurement of supplies and services.

1.11. Photometric Basis. Photometric requirements specified in this document are drawn from standards established by the ICAO. They have been augmented and modified as necessary to accommodate Air Force requirements.

1.12. Existing Facilities. Do not use this document as a sole basis for advancing standards for existing facilities and equipment, except where necessary for a minimum acceptable level of safety, quality, and performance. You may continue to support existing systems with equipment fabricated to the original specifications until the system is upgraded. If there is a change in mission which results in reclassification of the facility, an upgrade to current standards is required. When existing facilities are modified, construction must conform to the criteria in this document unless waived in accordance with paragraphs 1.8 and 1.9. If co-mingling of new generation equipment with older equipment is required, make sure the difference in performance does not degrade the system in any way.

1.13. Document Organization. This document has two parts:

1.13.1. Part 1: Contains the standards which each visual air navigational facility must meet. The information in Chapters 1 through 11 serves as siting criteria for the design of specific installations. This part also provides application criteria to ensure that planned installations are appropriate for their intended purpose.

1.13.2. Part 2: Chapters 12 through 15 contain information for each system including an explanation as to purpose, configuration, construction, photometrics, and related equipment guidelines as approved for US Army and Air Force use.

1.13.3. UFC 3-535-02, *Design Drawings for Visual Air Navigation Facilities*, supplements this document by providing guidance and detailed information on standard configurations and equipment. It is composed of drawing details for design and construction of individual components of visual navigation facilities. The drawings are also available in AutoCAD format at web site <http://cadlib.wes.army.mil>.

Chapter 2

APPLICATION CRITERIA

2.1. Purpose of Chapter. This chapter provides application criteria to ensure that the installation of visual air navigation facilities is appropriate for its intended purpose and that it is sufficient to achieve the desired level of operation.

2.2. Relation to Electronic Facilities. Except for VFR operation, electronic facilities are required to provide initial positioning and direction information to an approaching aircraft. Visual air navigation aids are required to ensure a timely and safe transition from the instrument phase of an approach to its visual phase. The planned operational level for an instrument runway can only be achieved through a combination of appropriate electronic and visual guidance systems. Failure to include required visual aids in the planning of an instrument runway will degrade the utility of the electronic systems. Conversely, enhancing of a runway with inappropriate visual aids will waste resources with little operational advantage.

2.3. Application of Requirements. Use the application criteria in this chapter for planning, budgeting, and installing visual air navigation facilities. Do not initiate the addition or upgrading of visual aids to a higher order of operational requirement unless the runway, taxiway, or helipad has been officially approved for the new level of operation and appropriate electronic aids have been installed or are programmed for installation. Waivers are required for all deviations in accordance paragraph 1.8 or 1.9, as applicable.

2.4. Matrix of Requirements. The matrix of requirements for Air Force airfields is shown in table 2.1A. and for US Army airfields is shown in table 2.1B. The matrix of requirements for helipads/heliports is shown in table 2.2. Each matrix contains application criteria for operational categories and the related visual aid requirements.

2.4.1. Not Required (NR) designates a visual aid which is not required for a particular operation and is therefore not specifically provided to support it.

2.4.2. Not Applicable (NA) designates a visual aid whose operational performance is not adequate to support a particular operation or where a particular operation that could be supported is not required.

2.5. Reference Documents. Use the most current revision or publication date for documents referenced in this document.

Table 2.1A. Visual Facilities AIR FORCE Airfield Requirements Matrix.

FACILITY	OPERATIONAL		CATEGORY		
	NIGHT VMC	NON- PRECISION	I	II	III
APPROACH AIDS					
High Intensity Approach Light System (ALSF-1)	NR	NR	R(1)	NA	NA
High Intensity Approach Light System (ALSF-2)	NR	NR	NR	R	R
Short Approach Lighting (SALS)	NR	OPT	NA	NA	NA
Simplified Short Approach Lighting (SSALR)	NR	OPT	OPT	NA	NA
Medium Intensity Approach Light System (MALSR)	NR	NR	OPT	NA	NA
Runway End Identifier Lights (REIL)	OPT	OPT	OPT	NA	NA
Precision Approach Path Indicator (PAPI)	R(2)	R(2)	OPT	NA	NA
RUNWAY AIDS					
High Intensity Runway Edge Lights (HIRL)	R	R	R	R	R
Medium Intensity Runway Edge Lights (MIRL)	OPT	OPT	NA	NA	NA
Threshold Lights	R	R	R	R	R
Runway End Lights	R	R	R	R	R
Runway Distance Markers (RDM)	R	R	R	R	R
Runway Centerline Lights (RCL)	NR	NR	NR	R	R
Touchdown Zone Lights (TDZL)	NR	NR	NR	R	R
TAXIWAY AIDS					
Taxiway Edge Lights	R	R	R	R	R
Taxiway Centerline Lights	OPT	OPT	OPT	OPT	R
Taxiway Clearance Bar (Hold Point)	NR	NR	NR	R	R
Runway Guard Lights	OPT	OPT	OPT	R	R
Runway Exit Lights	OPT	OPT	OPT	OPT	R
Taxiway Guidance Signs (Informative)	OPT	OPT	OPT	OPT	OPT
Taxiway Guidance Signs (Mandatory)	R	R	R	R	R
MISCELLANEOUS AIDS					
Airfield Identification Beacons	R	R	R	R	R
Wind Cones	OPT	OPT	OPT	NA	NA
Obstruction Lights	R	R	R	R	R
Emergency Power	R(3)	R(3)	R(3)	R(3)	R(3)
Legend: R Required. OPT Option as recommended by the wing commander and approved by the MAJCOM. NR Not required. NA Not applicable. Not appropriate for this application. (1) MAJCOM approval is required to substitute MALSR for an ALSF-1. (2) Required only on primary instrument runways. (3) Emergency power required for all "R" equipment.					
NOTE: Backup power must be provided for visual landing aid listed as (R) Required.					

Table 2.1B. Visual Facilities US ARMY Airfield Requirements Matrix.

FACILITY	OPERATIONAL		CATEGORY
	NIGHT VMC	NON- PRECISION	Precision Approach (IMC) I
APPROACH AIDS			
High Intensity Approach Light System (ALSF-1)	NR	NR	OPT
High Intensity Approach Light System (ALSF-2)	NR	NR	NR
Short Approach Lighting (SALS)	NR	OPT	NA
Simplified Short Approach Lighting (SSALR)	NR	OPT	OPT
Medium Intensity Approach Light System (MALSR)	NR	OPT	R
Runway End Identifier Lights (REIL)	OPT	OPT	OPT
Precision Approach Path Indicator (PAPI) (5)	OPT	OPT	OPT
RUNWAY AIDS			
High Intensity Runway Edge Lights (HIRL)	NR	NR	R
Medium Intensity Runway Edge Lights (MIRL)	R(1)	R(1)	NA
High Intensity Threshold Lights	NR	NR	R
Medium Intensity Threshold Lights	R	R	NA
Runway End Lights	R	R	R
Runway Distance Markers (RDM)	R	R	R
Runway Centerline Lights (RCL)	NR	NR	NR
Touchdown Zone Lights (TDZL)	NR	NR	NR
TAXIWAY AIDS			
Taxiway Edge Lights	R	R	R
Taxiway Centerline Lights	NR	NR	NR
Taxiway Hold Lights/Stop Bar	NR	NR	NR
Runway Exit Lights	OPT	OPT	OPT
Runway Guard Lights	OPT	OPT	OPT
Guidance Signs (Informative) (3)	R	R	R
Guidance Signs (Mandatory) (3)	R	R	R
MISCELLANEOUS AIDS			
Airfield Identification Beacons	R	R	R
Wind Cones (2)	R	R	R
Obstruction Lights	R	R	R
Emergency Power	R(4)	R(4)	R(4)
Legend:			
R	Required.		
OPT	Option as determined by the airfield commander and approved by USAASA.		
NR	Not required.		
NA	Not applicable.		
(1)	Use with medium intensity threshold lights.		
(2)	A lighted Style 1 wind cone; aviation community to determine size.		
(3)	See FAA AC 150/5340-18 for guidance.		
(4)	Emergency power required for all “R” equipment.		
(5)	See paragraph 3.7.1.1 for additional guidance.		

Table 2.2. Visual Facilities Helipads/Heliports Requirements Matrix.

FACILITY	HELIPAD/HELIPORT				Helicopter Runway
	VMC	VMC	IMC		IMC
	Day Non- Instrument	Night Non Instrument	Non- Precision Instrument	Precision Instrument Category I	Precision Instrument Category I
Perimeter Lights	NA	R	R	R	NA
Approach Direction Lights	NA	OPT	R	NA	NA
Landing Direction Lights	NA	OPT	R	NA	NA
Approach Lights Category I	NA	NA	NA	R	R
Floodlights	NA	OPT	OPT	OPT	OPT
Visual Glide Slope Indicator System (4)	NA	OPT	OPT	OPT	OPT
High Intensity Runway Edge Lights	NA	NA	NA	NA	R
Threshold Lights	NA	NA	NA	NA	R
Runway End Lights	NA	NA	NA	NA	R
Taxiway Lights	NA	OPT	OPT	OPT	R
Illuminated Heliport - Guidance Signs (2)	R(1)	R	R	R	R
Obstruction Lighting	R	R	R	R	R
Electrical Supply Standby Generator	NA	OPT	R	R	R
Hoverlane Lighting	NA	OPT	R	R	R
Identification Beacon	R	R	R	R	R
Apron Lighting	NA	OPT	OPT	OPT	OPT
Wind Direction Indicator	R(1)	R	R	R	R
Emergency Power	R(4)	R(4)	R(4)	R(4)	R(4)
Legend: R Required. OPT Optional NA Not applicable. (1) Not lighted for DAY VMC. (2) See FAA AC 150/5340-18 for guidance. (3) Emergency power required for all "R" equipment. (4) See paragraph 7.5.2 Justification.					
NOTE: Refer to chapters 7 & 8 for criteria.					

Chapter 3

STANDARDS FOR LIGHTED APPROACH AIDS

3.1. Approach Light System with Sequenced Flashing Lights, (ALSF-1):

3.1.1. Purpose. The ALSF-1 is a high intensity approach lighting system with sequenced flashing lights where operations under Category I conditions are required. This system provides the visual guidance to pilots for

alignment of the approaching aircraft with the runway and for final corrections before landing at night and during low visibility weather conditions.

3.1.2. Associated Systems. In addition to electronic aids such as ILS, PAR, or Microwave Landing System (MLS), the ALSF-1 should include the following:

3.1.2.1. The runway should be paved and not less than 50 meters (150 feet) wide. The length should not be less than 2,000 meters (6,000 feet), but shorter lengths may be approved for special operating conditions.

3.1.2.2. The runway must be equipped with the following:

3.1.2.2.1. Precision approach runway markings.

3.1.2.2.2. High-intensity runway edge lights.

3.1.2.2.3. High-intensity threshold lights.

3.1.2.2.4. Runway end lights.

3.1.2.3. The approach should have a paved or stabilized end zone area extending 300 meters (1,000 feet) into the approach area and not less than the runway width. The first 100 meters (300 feet) of this paved or stabilized area should have the same slope as the first 300 meters (1,000 feet) of the runway. The remainder of the paved or stabilized area may have a slope of not more than ± 1.5 percent. This criteria and further details are provided in UFC 3-260-01, *Airfield and Heliport Planning and Design*.

3.1.2.4. The runway should have a Runway Visual Range (RVR) system.

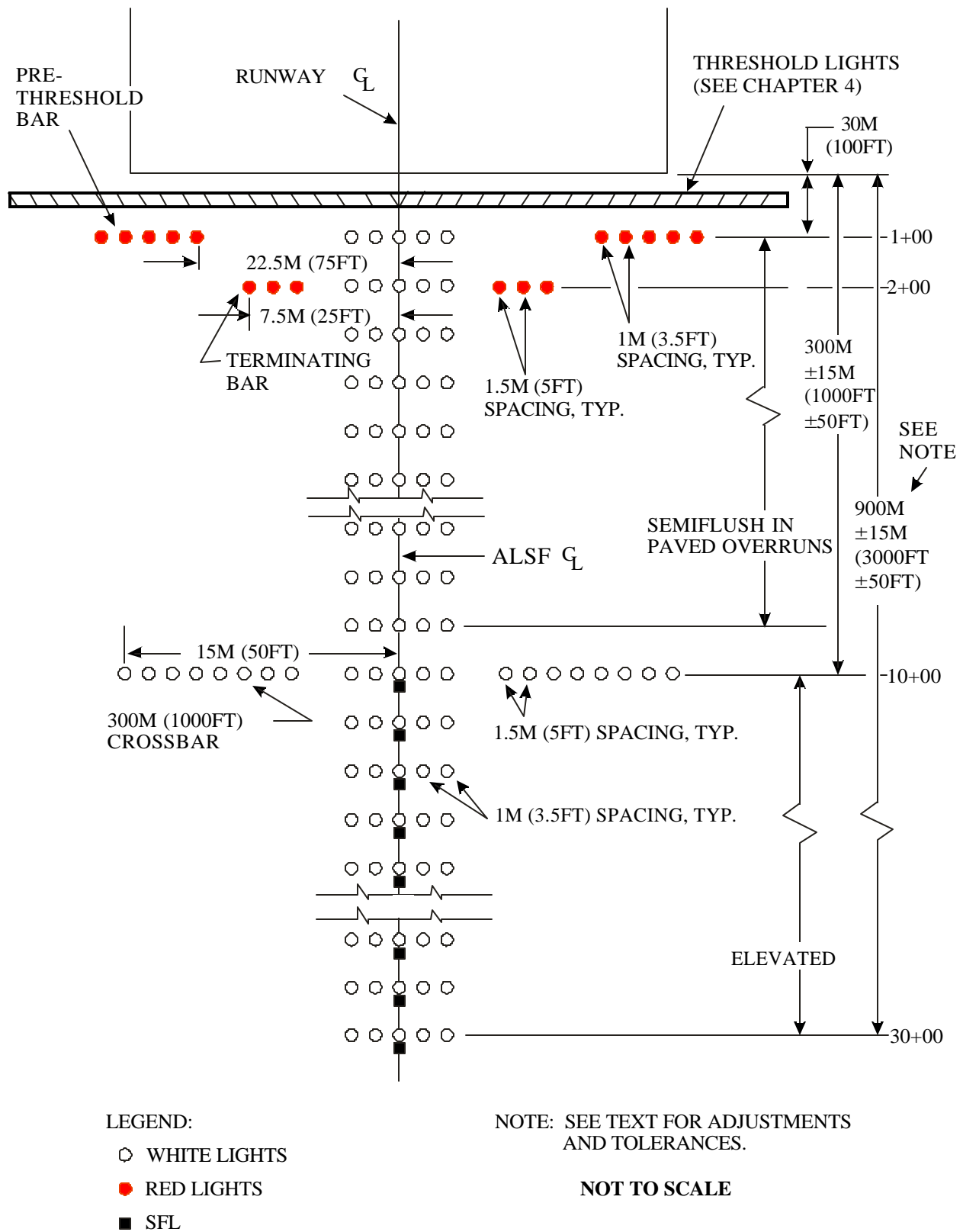
3.1.2.5. Air traffic control should be provided during normal operating hours.

3.1.3. Configuration. The ALSF-1 consists of a pre-threshold light bar, a terminating bar, a 300 meter (1,000 foot) crossbar, centerline lights, sequenced flashing lights, and threshold lights. Figure 3.1 shows the typical layout. The system centerline coincides with the extended runway centerline. The overall system length is 900 meters (3,000 feet) extending from the runway threshold into the approach zone. For the Air Force only, if terrain or other local conditions prevent a full-length installation, the system may be shortened to not less than 720 meters (2,400 feet). There is a generally accepted convention for locating lights along the longitudinal axis of approach light systems for this standard. The longitudinal axis is divided into 30 meter (100 foot) stations with station 0+00 located at the threshold and higher station numbers located further into the approach. Thus, a light at station 1+34 would be located 40.3 meters (134 feet) into the approach from the threshold. All lights in the system are aimed toward the approach. Required locations and configurations of the individual system elements are:

3.1.3.1. Pre-threshold Bar. The pre-threshold bar consists of two barrettes in aviation red lights placed symmetrically about the system centerline at station 1+00. Each barrette consists of five lights on 1 meter (3.5 feet) centers, with the innermost lights located not less than 22.5 meters (75 feet) nor more than 24 meters (80 feet) from the system centerline.

3.1.3.2. Terminating Bar. The terminating bar consists of two barrettes in aviation red lights located symmetrically about and perpendicular to the system centerline at station 2+00. Each barrette consists of three lights on 1.5 meter (5 foot) centers, with the outermost lights located 7.5 meters (25 feet) from the system centerline.

Figure 3.1. ALSF-1 Configuration.



3.1.3.3. 300 meter (1,000 foot) Crossbar. This crossbar consists of two barrettes in aviation white lights located symmetrically about and perpendicular to the system centerline at station 10+00 and in line with the centerline barrette at that station. Each barrette consists of 8 lights on 1.5 meter (5 foot) spacing with the outermost light located 15 meters (50 feet) from the system centerline.

3.1.3.4. Centerline Lights. The centerline lights consist of a series of barrettes in aviation white lights located at 30 meter (100 foot) intervals along the system centerline, from station 1+00 to station 30+00. Each barrette consists of five lights spaced at 1 meter (3.5 feet) on centers, centered on and perpendicular to the system centerline. Centerline lights installed on elevated supports may be spaced at 1.02 meters (40.5 inches) in order to fit standard support hardware.

3.1.3.5. Sequenced Flashing Lights (SFL). The sequenced flashing lights are a series of flashing lights located on the system centerline at each station, beginning at station 10+00, 300 meters (1,000 feet) to the end of the system at station 30+00. The lights flash a bluish-white light at a rate of twice per second in sequence from the outermost light station toward the threshold, appearing as a ball of white light traveling toward the runway. Sequenced flashing lights may be uniformly mounted a maximum of 1.3 meters (4 feet) below the steady burning lights or, when in-pavement lights are used, they may be displaced a maximum of 1.5 meters (5 feet) into the approach along the system centerline in order to avoid visual or physical interference between light units.

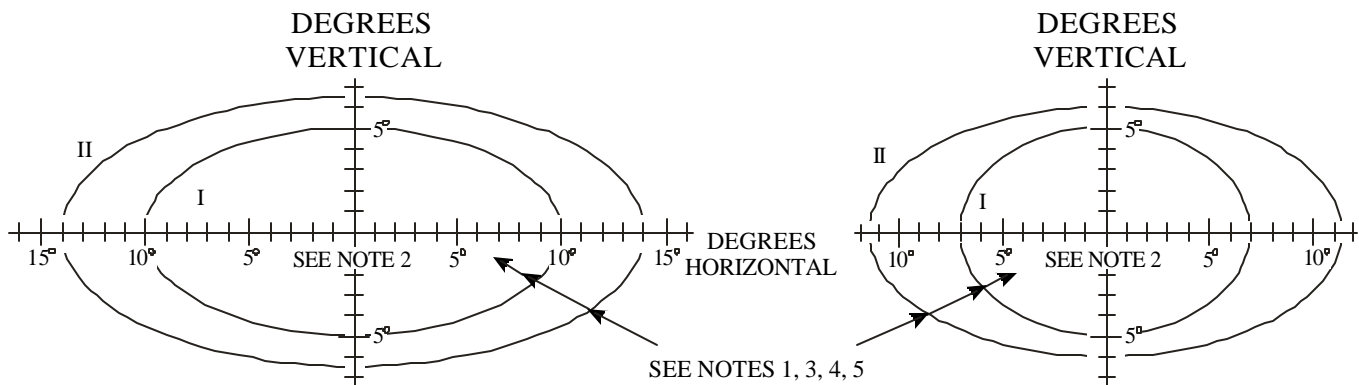
3.1.3.6. Threshold Lights. While threshold lights are not actually a section of the approach light system, they must be present and installed according to paragraph 4.4.

3.1.4. Photometrics. Optimum aiming of lights depends on the design and light output of the fixtures used in the system. Light fixtures may be designed to cover several applications and may have fixed patterns and aiming angles which differ from the standard. Light aiming and patterns other than those given in this standard may be used, provided the resultant light pattern produces equivalent light intensities in the areas required by the standard. Luminous characteristics for the lights used in this system are described below. The beam widths are measured symmetrically about the optical axis of the light unit unless otherwise noted. All steady burning lights used in the system must meet the intensity requirements given in figure 3.2. Sequenced flashing lights must provide, at the maximum intensity setting, an effective intensity of 15,000 candelas (cd) in an elliptical area subtending beam angles of ± 15 degrees horizontally and ± 5 degrees measured vertically from the beam axis.

3.1.4.1. Intensity Control. Provide brightness control with five intensity steps for steady burning lights and three intensity steps for flashing lights. Couple the intensity of the sequenced flashing lights to the intensity of the steady burning lights as follows:

Intensity step	Steady Light	Flashing Light
	Intensity <u>Percentage</u>	Intensity <u>Percentage</u>
1	0.16	2.00
2	0.8	2.00
3	4.00	10.00
4	20.00	100.00
5	100.00	100.00

Figure 3.2. Approach Lighting Photometrics.



**A. ELEVATED APPROACH LIGHTS; CENTERLINE
300M (1000FT) CROSSBAR (STA 10+00 TO 30+00)**

	I=50%	II=10%
a	10.0°	14.0°
b	5.0°	6.5°

**B. SEMIFLUSH WHITE OR RED APPROACH LIGHTS;
CENTERLINE OR SIDE ROW (STA 1+00 TO 9+00)**

	I=50%	II=10%
a	7.0°	11.5°
b	5.0°	6.0°

NOTES:

1. ALL CONTOURS ARE ELLIPSES CALCULATED BY EQUATION $\frac{X^2}{a^2} + \frac{Y^2}{b^2} = 1$
2. THE MINIMUM AVERAGE INTENSITY OF THE MAIN BEAM (INSIDE CONTOUR I) IS 20,000 CD FOR WHITE, OR 5000 CD FOR RED.
3. MAXIMUM INTENSITY SHOULD NOT EXCEED 1.5 TIMES ACTUAL AVERAGE INTENSITY.
4. MINIMUM INTENSITY OF I=50% AND II=10% OF REQUIRED MAIN BEAM INTENSITY.
5. FOR SEMIFLUSH UNITS, THE PORTION OF LIGHT CUT OFF BY THE MOUNTING SURFACE MAY BE DISREGARDED.

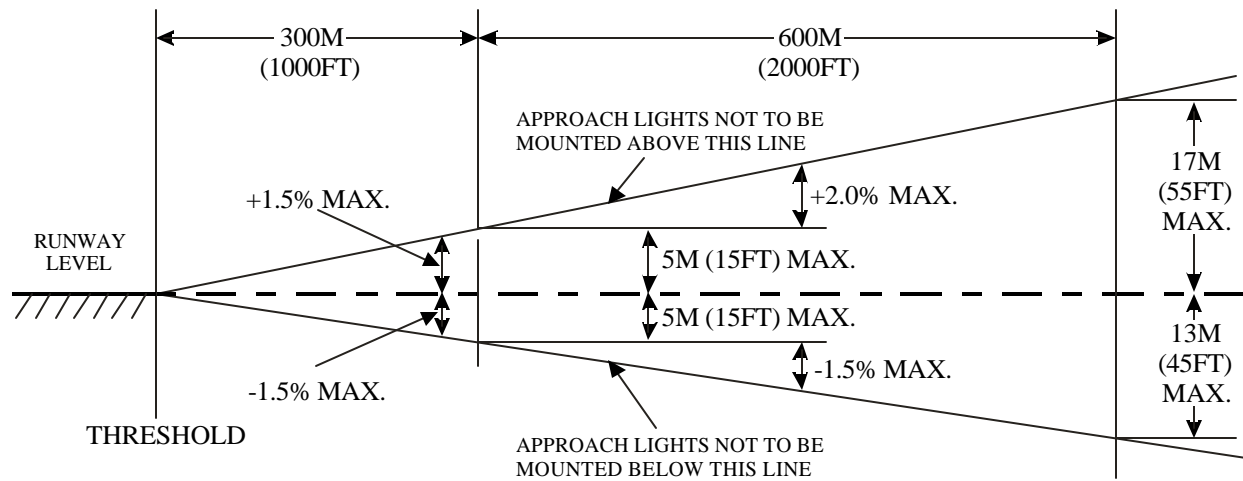
3.1.4.2 Aiming Criteria. Aim the beams of all approach lights into the approach zone and away from the threshold, with the beam axis parallel to the extended runway centerline. Vertical aiming of the elevated, uni-directional, steady burning lights at the elevation angles in accordance with table 3.1. These aiming angles are based on a three degree glide slope. If other glide slope angles are used, adjust the vertical aiming for the same degree of difference. Some existing SFL may have fixed angles for the beam. Refer to paragraph 4.4.9 when threshold lights are used as part of an approach system.

Table 3.1. Elevation Setting Angles for ALSF-1.

STEADY-BURNING TYPE FAA-E-982 LIGHTS					
Station	Setting Angle above Horizontal* (Degrees)		Station	Setting Angle above Horizontal * (Degrees)	
	Preferred	Permitted		Preferred	Permitted
30+00	8.0	8.0	14+00	7.0	7.0
29+00	7.9	8.0	13+00	6.9	7.0
28+00	7.9	8.0	12+00	6.9	7.0
27+00	7.8	8.0	11+00	6.8	7.0
26+00	7.7	7.5	10+00	6.7	6.5
25+00	7.6	7.5	9+00	6.7	6.5
24+00	7.6	7.5	8+00	6.6	6.5
23+00	7.6	7.5	7+00	6.5	6.5
22+00	7.5	7.5	6+00	6.5	6.5
21+00	7.4	7.5	5+00	6.4	6.5
20+00	7.4	7.5	4+00	6.3	6.5
19+00	7.3	7.5	3+00	6.3	6.5
18+00	7.2	7.0	2+00	6.2	6.0
17+00	7.2	7.0	1+00	6.2	6.0
16+00	7.1	7.0	0+00	6.1	6.0
15+00	7.0	7.0			
* For approach slopes other than 3 degrees, adjust the setting angles for the difference. Tolerances are ± 0.2 degrees. Elevated SFL are all aimed 6 degrees above horizontal.					

3.1.4.3. Obstruction Clearances. A light plane or planes in which the lights of the system are located, are used for determining obstruction clearances of the approach lights. The side boundaries of the light plane are 60 meters (200 feet) on each side of the runway centerline extended. The end boundaries are at the runway threshold and at 60 meters (200 feet) before the start of the approach light system. All lines in the plane perpendicular to the centerline are level. The ideal light plane (figure 3.3) is a single horizontal plane through the runway threshold. If the 300 meters (1,000 feet) of the runway at the threshold end is sloped, the first 100 meters (300 feet) of the paved or stabilized area of the approach zone and the light plane for this area must continue with the same slope. The final 235 meters (700 feet) of the paved or stabilized area may have a slope of not more than 1.5 percent up or down. From the 300 meter (1,000 foot) crossbar to the beginning of the approach light system, the preferred light plane is horizontal and includes the 1,000-foot crossbar lights. If the clearance of obstructions or terrain prohibits using a horizontal light plane, this plane may be sloped. The slope of this plane must not exceed 2 percent up or 1.5 percent down. The preferred light plane in the area beyond the 300 meter (1,000 foot) crossbar is a single plane, but changes in the slope of the plane are permitted. All light planes start and end at a light station and contain not less than three light stations.

Figure 3.3. Light Plane Elevation Limits.



NOTE: THE BOUNDARIES OF THE LIGHT PLANES ARE THE RUNWAY THRESHOLD, 60M (200FT) AHEAD OF THE END LIGHT STATION, AND 60M (200FT) EACH SIDE OF CENTERLINE.

3.1.4.4. Light plane obstructions. No objects may penetrate the light plane except for ILS components and components of airfield lighting systems which are fixed by their function. These components must not interfere with the pilot's view of the approach lights when on a normal approach and must be obstruction lighted. For clearance purposes, all roads, vehicle parking areas and railroads are considered as vertical solid objects. The required clearance above railroads is 7.5 meters (23 feet) and above interstate highways is 6 meters (17 feet). The clearance required above other public roads and parking lots is 5 meters (15 feet). The clearance above private and military roads is 3 meters (10 feet). Airfield service roads, where traffic is controlled, are not considered as obstructions. Control of the service road traffic must be accomplished by appropriate signs or directly by the control tower; parking or stopping is prohibited between the signs. The Airfield Commander must approve the means of control and the wording of signs. It is preferred to get the needed clearance above a road, rather than controlling the traffic so the clearance is not necessary. Obstructions beyond the approach light system will be in accordance with UFC 3-260-01, *Airfield and Heliport Planning Design*.

3.1.4.5. Configuration Adjustments. Siting considerations may require adjustment of the approach light system configuration. The following adjustments are permissible without a waiver:

3.1.4.5.1. System Centerline. The system centerline may be offset laterally a distance of not more than 0.6 meters (2 feet) to maintain alignment with runway centerline lights or to avoid installation problems.

3.1.4.5.2. Light Station Adjustments. To avoid roads, buildings, railroads, or other obstacles, it may be necessary to move a light station away from its nominal location. Where this is so, change the light bar spacings to distribute the difference uniformly so the spacing between adjacent light stations is kept at 30 meters \pm 3 meters (100 feet \pm 10 feet) and the system length is maintained.

3.1.4.6. Construction Tolerances. The tolerances for positioning ALSF-1 and ALSF-2 lights are as follows:

3.1.4.6.1. Light stations must be installed longitudinally within 150 millimeters (6 inches) of the designated location.

3.1.4.6.2. The lateral tolerance for installation of a light bar is \pm 75 millimeters (\pm 3 inches).

3.1.4.6.3. The tolerance for distance between individual lights is \pm 25 millimeters (\pm 1 inch).

3.1.4.6.4. Mounting heights tolerances are:

Support Height Tolerances

0-2M (0-6 ft)	25 mm (1 in.)
2-12M (6 – 40 ft)	50 mm (2 in.)
12+ M (40+ ft)	75 mm (3 in.)

3.1.4.6.5. Deviation from a line perpendicular to the Approach Landing System (ALS) centerline is ± 25 millimeters (± 1 inch) maximum.

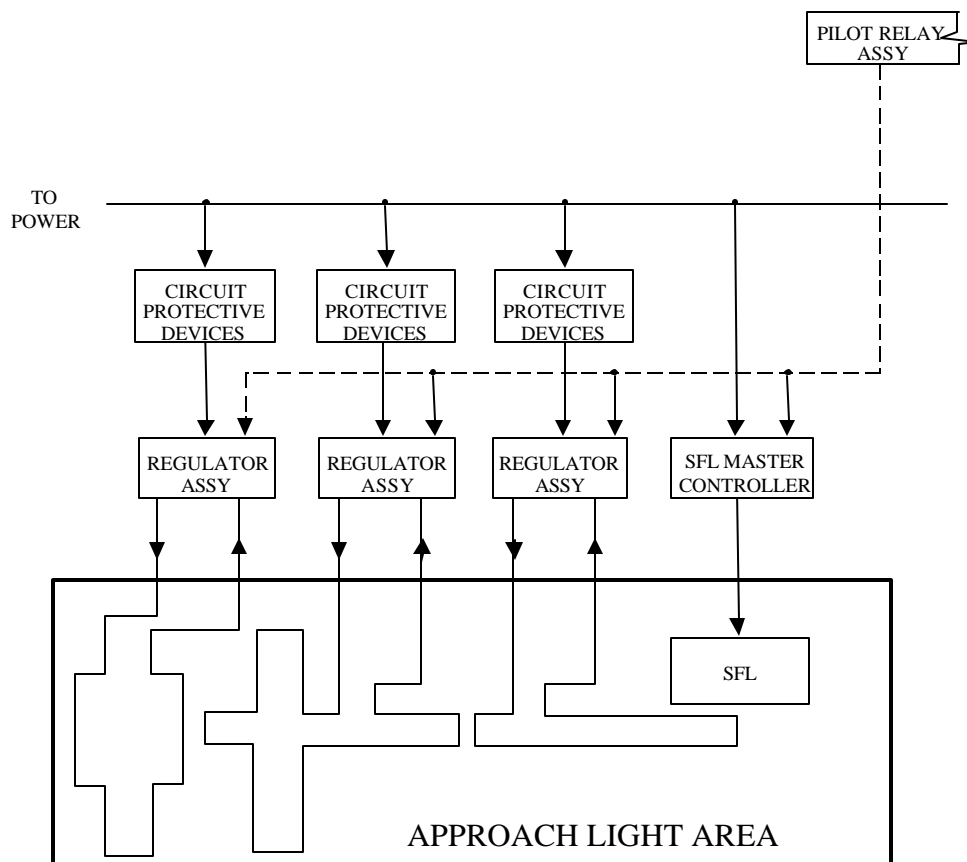
3.1.4.6.6. Vertical angular alignment of a light must be within 1 degree.

3.1.4.6.7. Horizontal angular alignment of a light must be within 5 degrees.

3.1.4.6.8. Light stations must be installed within 150 millimeters (6 inches) of the station designation.

3.1.5. Power Requirements. Provide a main and on-site standby power system with automatic transfer within 15 seconds of a failure of the power system in use. Do not locate the power and control substation or the standby power equipment within the approach light area, shown in figure 3.4.

Figure 3.4. Block Diagram-Approach Lighting, ALSF-1.



3.1.6. Control Requirements. Provide remote on and off and five-step intensity control for the steady burning lights. Provide new systems or systems receiving major upgrades with the capability of being electrically

switched from the ALSF-1 configuration to the SSALR configuration described in paragraph 3.4. Provide a selector switch in the control tower to switch from ALSF-1 to SSALR.

3.1.7. Monitoring Requirements. Monitoring is required if the runway will be used when the RVR is below 720 meters (2,400 feet).

3.1.8. Equipment. See paragraph 13.9.1 for typical ALSF-1 components.

3.1.8.1. Fixtures. Use in-pavement fixtures in paved overruns and in displaced thresholds, or where they are subject to damage by jet blast. No part of the unit must extend more than 25 millimeters (1 inch) above surrounding pavement. All other fixtures must be elevated and capable of being aimed as required by the standard.

3.1.8.2. Fixture Support. Support elevated fixtures on frangible, low-impact resistant, or semi-frangible supports depending on the required mounting height:

<u>Mounting Height</u>	<u>Support Type</u>
0-2 meters (0-6 ft)	Frangible
2-12 meters (6-40 ft)	Low Impact Resistant
12+ meters (40+ ft)	Semi-frangible

3.1.9. Compliance with International Military Standards:

3.1.9.1. ASCC. This standard meets the requirements for a type B approach light system, as described in ASCC AIR STD 90/27, *Aerodrome Lighting*, Section One.

3.1.9.2. NATO. This standard meets requirements for a Type II approach lighting system as described in NATO STANAG 3316, *Airfield Lighting*, except for the vertical aiming of the lights.

3.2. Approach Light System With Sequenced Flashing Lights, (ALSF-2):

3.2.1. Purpose. The ALSF-2 is a high intensity approach light system for operations under Category II or Category III conditions.

3.2.2. Configuration. The ALSF-2, as shown in figure 3.5, is configured as an ALSF-1 system modified as follows:

3.2.2.1. Pre-threshold Bar. The red lights at the pre-threshold bar are removed.

3.2.2.2. Terminating Bar. The red lights at the terminating bar are removed.

3.2.2.3. 150 Meter (500 Foot) Bar. A 150 meter (500 foot) bar is added. It consists of two barrettes of aviation white lights, located symmetrically about and perpendicular to the runway centerline, in line with the centerline barrette at that station. Each barrette consists of four aviation white lights on 1.5 meter (5 foot) centers, centered in the space between the centerline lights and the side row lights.

3.2.2.4. Side Row Lights. Side row lights are added to the inner nine lights stations at stations 1+00 through 9+00. They consist of barrettes containing three aviation red lights, located symmetrically about and perpendicular to the extended runway centerline at each of the light stations 1+00 through 9+00. the lights in each barrette are on 1.5 meter (5 foot) centers, with the innermost light spaced 11 meters (36 feet) from the extended runway centerline.

3.2.3. Photometrics. The requirements in paragraph 3.1.4 for ALSF-1 apply.

3.2.4. Aiming Criteria. The aiming criteria as specified in paragraphs 3.1.4.2 through 3.1.4.5 for ALSF-1 apply, except that the red side row lights be aligned with any existing touchdown lights.

3.2.5. Power Requirements. Provide a main and a standby power system, with automatic transfer time within 1 second of a failure of the system that is in use. See system block diagram at figure 3.6 and Chapter 12 for additional design guidance.

3.2.6. Control Requirements. The control requirements in paragraph 3.1.6 for ALSF-1 systems apply. Provide a selector switch in the control tower to switch from ALSF-2 to SSALR.

3.2.7. Monitoring Requirements. Provide monitoring which, at a minimum, gives a positive indication at a control facility that power is being provided to the system.

3.2.8. Equipment. See paragraph 13.9.1; fixtures and supports for ALSF-1 apply.

3.2.9. Compliance with International Military Standards:

3.2.9.1. ASCC. This standard meets the requirements for a type C system as described in ASCC AIR STD 90/27.

3.2.9.2. NATO. This standard meets the requirements for a Type II system as described in NATO STANAG 3316 except for the vertical aiming of the lights.

Figure 3.5. ALSF-2 Configuration.

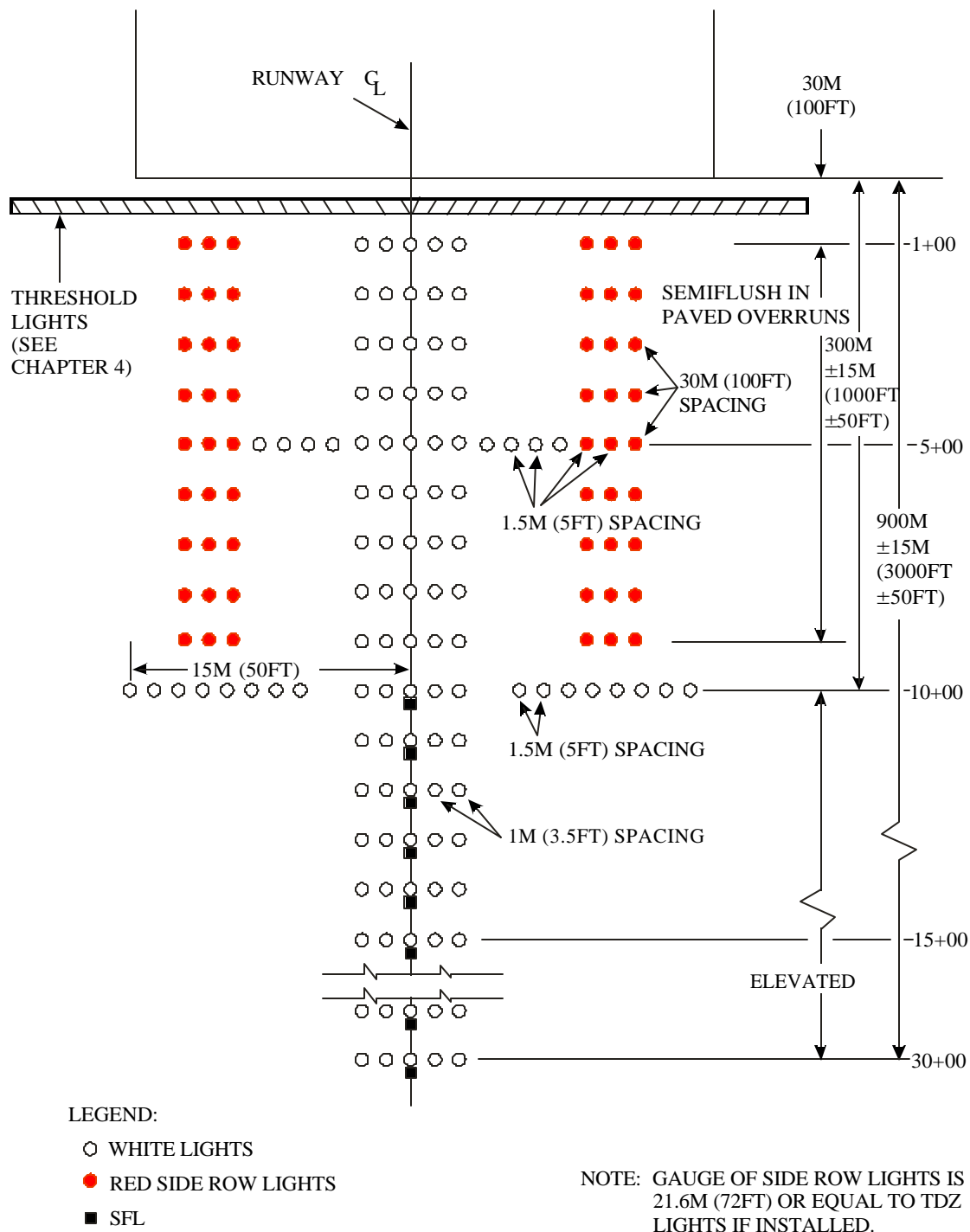
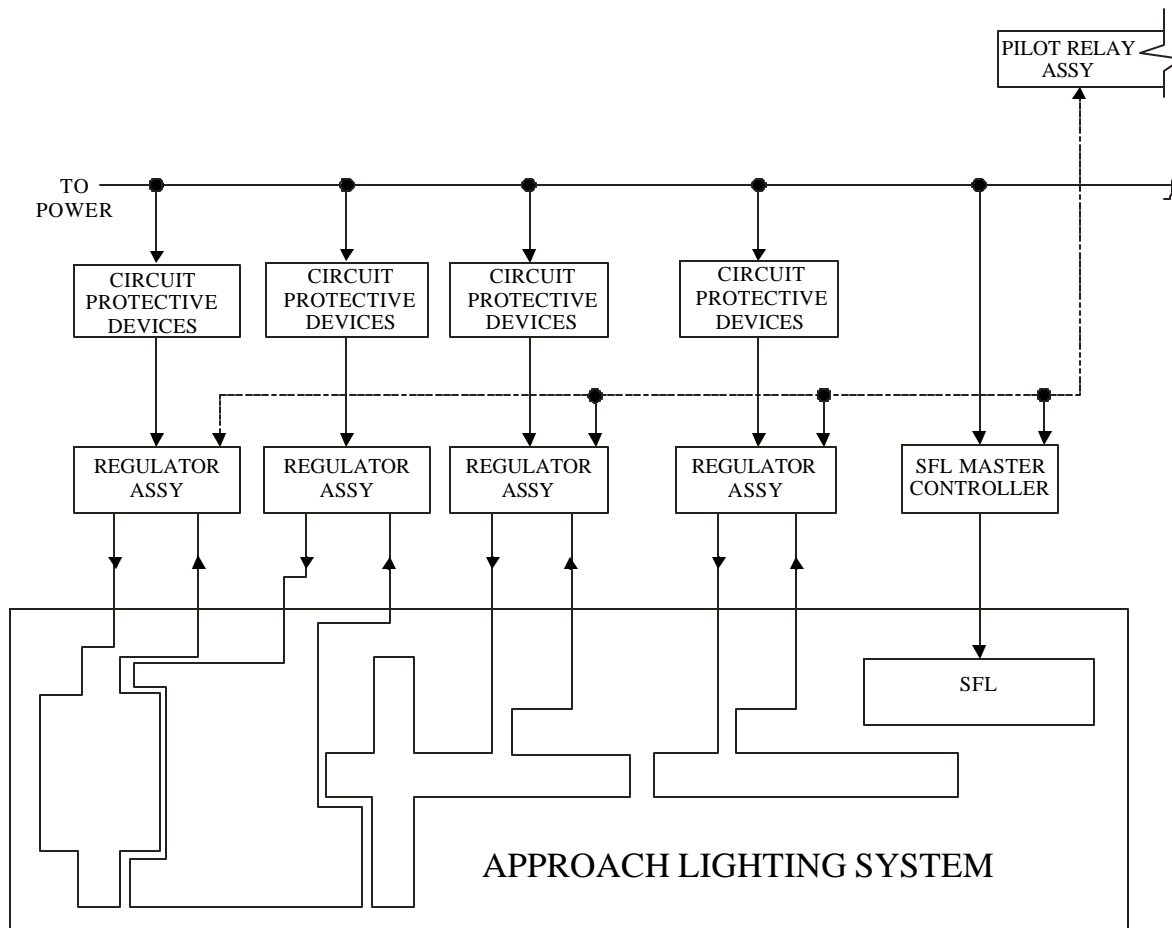


Figure 3.6. Block Diagram-Approach Lighting, ALSF-2.

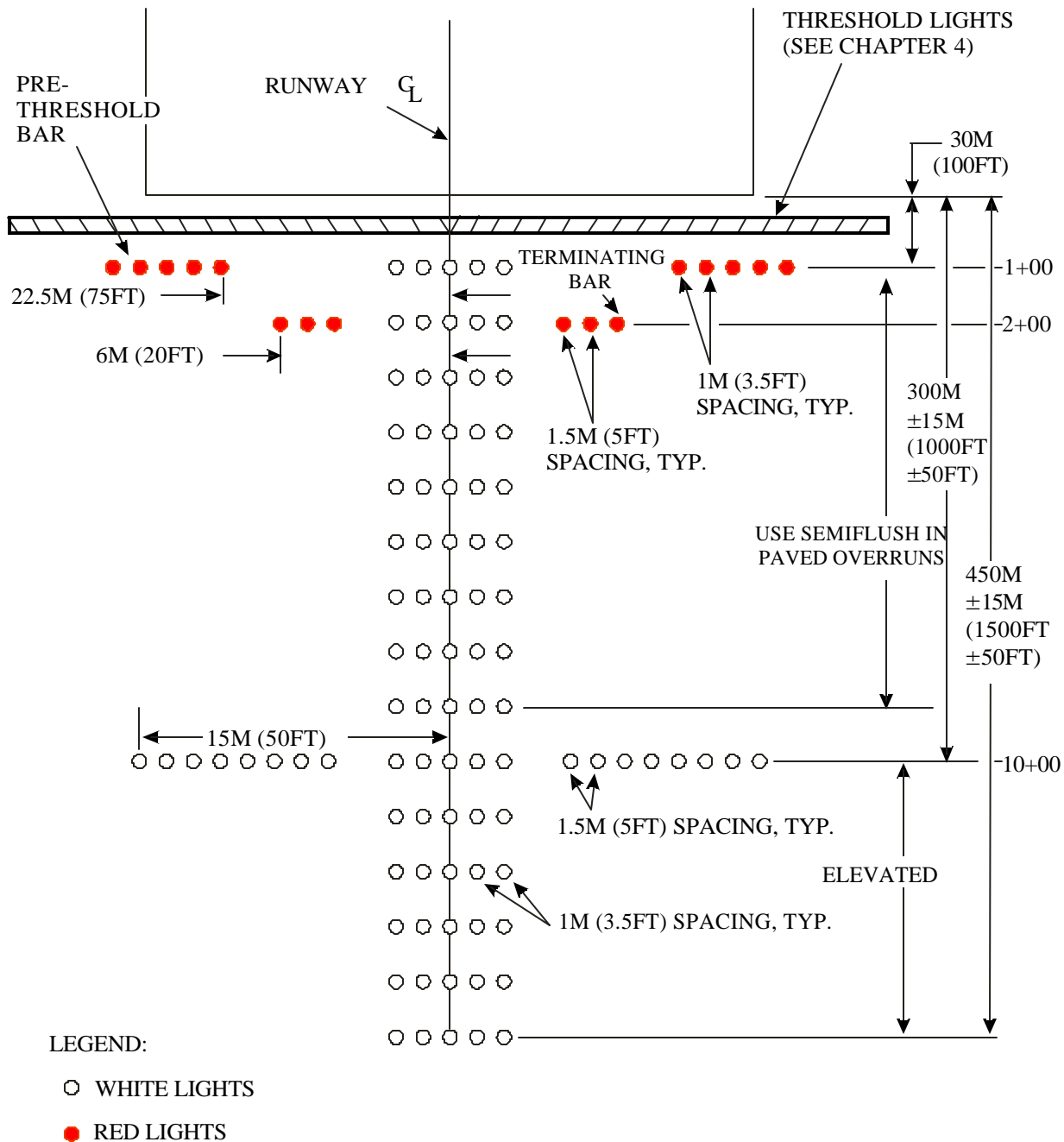


3.3. Short Approach Lighting System (SALS):

3.3.1. Purpose. The SALS is a high intensity approach light system used at locations where installation space is a problem and non-precision approaches are conducted. This configuration requires a waiver. See paragraph 1.8 or paragraph 1.9.

3.3.2. Configuration. The SALS, as shown in figure 3.7, is configured as an ALSF-1, except the system is 450 meters (1,500 feet) long and does not have sequenced flashing lights.

Figure 3.7. SALS Configuration.



3.3.3. Photometrics. The requirements in paragraph 3.1.4 for ALSF-1 apply.

3.3.4. Power, Control and Monitoring. The requirements in paragraphs 3.1.5 through 3.1.7 for the ALSF-1 system apply. See figure 3.4 for the system block diagram.

3.3.5. Equipment Used. See paragraph 13.9.1 for applicable components.

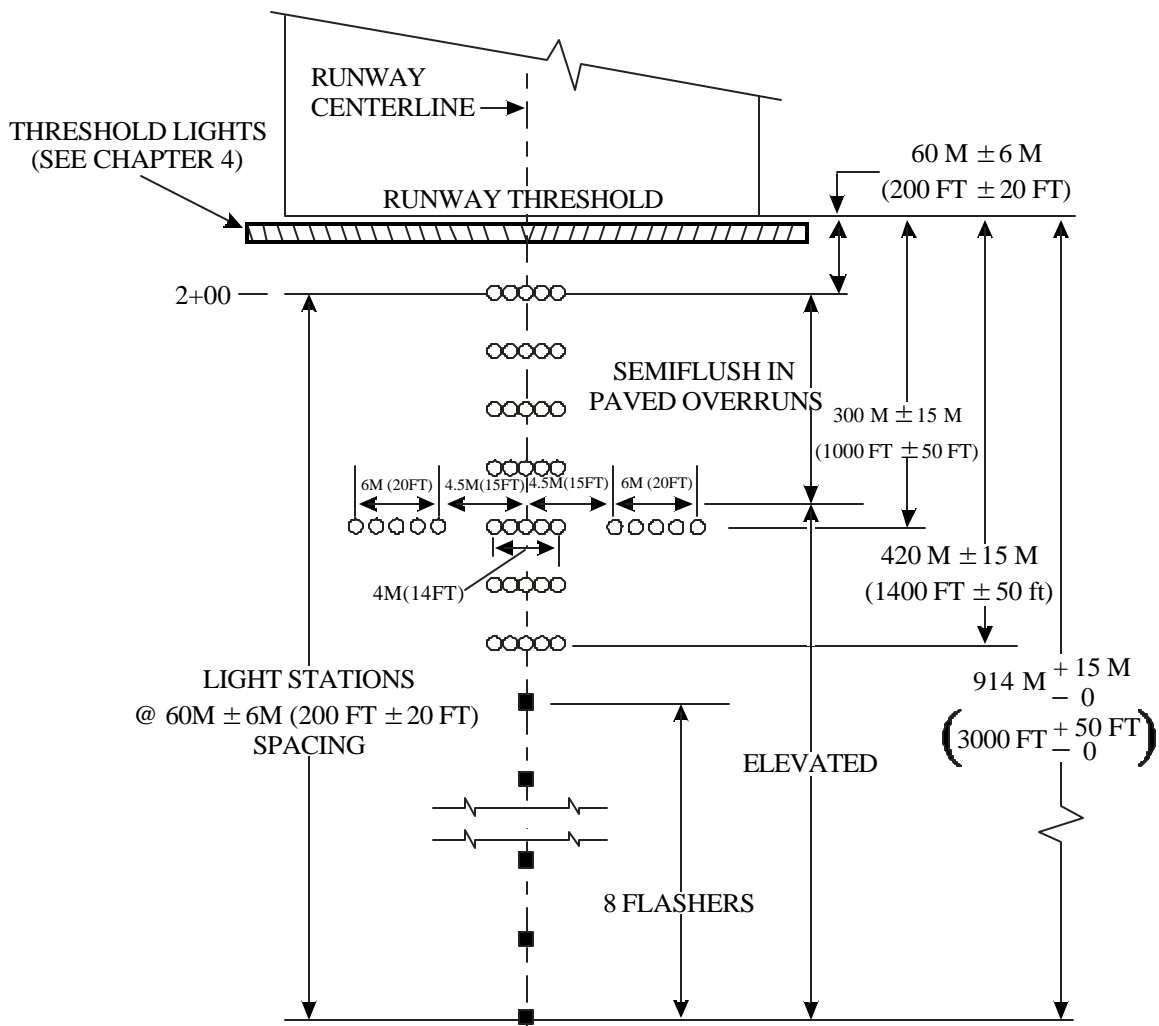
3.3.6. Compliance with International Standards. There are no equivalent systems in the ASCC or NATO standards.

3.4. Simplified Short Approach Lighting System with Runway Alignment Indicator Lights (SSALR):

3.4.1. Purpose. The SSALR is a simplified version of the ALSF-1 or ALSF-2. This system configuration is achieved by electrically switching off elements of an ALSF-1 or ALSF-2 for energy conservation purposes, when weather conditions permit.

3.4.2. Configuration. The SSALR, shown in figure 3.8, is configured as an ALSF-1, except that the outer 480 meters (1,600 feet) of the steady burning lights are inoperative as are the odd numbered light stations on the inner 300 meters (1,400 feet), the outer three lights at each end of the 1,000-foot bar, and the red lights in the terminating and pre-threshold bars. Also, the sequenced flashing lights are inoperative at stations 10+00 through 15+00 and at the odd numbered stations thereafter.

Figure 3.8. SSALR Configuration.



LEGEND:

○ STEADY-BURNING LIGHT

■ SFL

3.4.3. Other Requirements. All other requirements in paragraph 3.1 for ALSF-1 apply.

3.4.4. Compliance with International Standards. There are no equivalent systems in the ASCC or NATO standards.

3.5. Medium Intensity Approach Light System with Runway Alignment Indicator Lights (MALSR):

3.5.1. Purpose. The MALSR is a medium intensity approach light system with sequenced flashing lights used for runway alignment. This system provides visual approach area identification, centerline alignment, and roll reference for aircraft making approaches for landings during day or night operations. This configuration is FAA approved for ILS Category I approaches, but requires a waiver to be installed on an Air Force base. See paragraph 1.8.

3.5.2. Associated Systems. In addition to electronic aids such as ILS, which provide electronic guidance down to a minimum of not less than 60 meters (200 feet) Category I condition, the MALSR should include the following:

3.5.2.1. Non-precision or precision approach instrument runway markings.

3.5.2.2. High-intensity Runway edge Lights (HIRL).

3.5.2.3. Threshold lights or displaced threshold lights.

3.5.2.4. Precision Approach Path Indicator (PAPI).

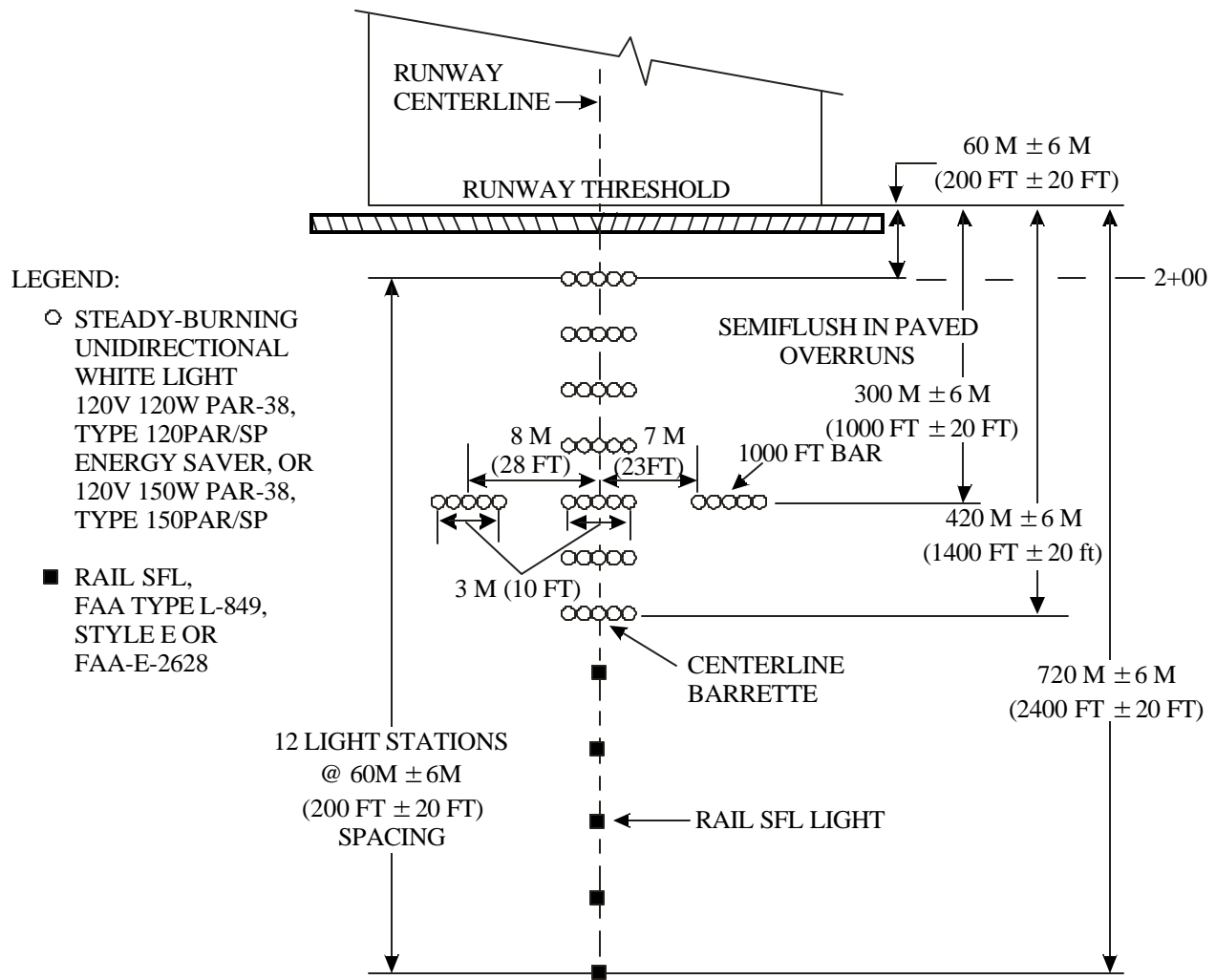
3.5.3. Configuration. The MALSR is a system of light bars, barrettes, and Sequenced Flashing Lights (SFL) in the approach zone immediately ahead of the runway threshold. The length of a MALSR is 720 meters (2,400 feet). The plan of the MALSR is shown in figure 3.9 and the schedule of lighting equipment is given in Chapter 13. The MALSR consists of centerline light barrettes, 300 meter (1,000 foot) crossbar, and the Runway Alignment Indicator Lights (RAIL). In the MALSR, a barrette is 5 lights closely spaced in a transverse line for which the length must not exceed 3 meters (10 feet) with the center-to-center spacing of the lights 0.75 meters (2.5 feet).

3.5.3.1. Centerline Light Barrettes. The centerline lights consist of seven 5-light barrettes of steady-burning, uni-directional, white, elevated lights. For runways with displaced thresholds or paved overruns, the centerline lights on the runway and overrun must be in-pavement. Normal configuration is 60 meters (200 feet) spacing starting 60 meters (200 feet) from the threshold and extending to 420 meters (1,400 feet).

3.5.3.2. 300 Meter (1,000 Foot) Crossbar. This crossbar consists of two barrettes in aviation white lights located symmetrically about and perpendicular to the system centerline at station 10+00 and in line with the centerline barrette at that station. Each barrette consists of 5 lights on 0.75 meter (2.5 foot) spacing with the innermost light located 7 meters (23 feet) from the system centerline. Lights located in paved areas must be in-pavement type.

3.5.3.3. Runway Alignment Indicator Lights (RAIL). The RAIL consists of five single SFL on the runway centerline in the approach area of the centerline barrette lights. These lights are capacitor-discharge, uni-directional, white, elevated lights which are flashed in sequence from the approach end towards the runway thresholds. Locate the SFLs between 480 meters and 800 meters (1,600 feet and 2,400 feet) from the runway threshold, spaced at 60 meters (200 feet) apart.

Figure 3.9. MALSR Configuration.



3.5.4. Photometrics. The color of the steady-burning lights must be aviation white for the centerline and 300 meter (1,000 foot) crossbar lights. The color of SFL may be aviation white or bluish-white, similar to xenon gas discharge lights. The intensity steps based on rated intensity must be 100 percent for high setting, 20 percent for medium setting, and 4 percent for low setting for the steady burning centerline and 30 meter (100 foot) crossbar lights; and 100 percent for high setting, 10 percent for medium setting, and 2 percent for low setting for the SFL. The SFL must flash in sequence from the outer end toward the runway threshold at a steady rate between 60 and 120 times per minute. The interval between flashes of adjacent lights must nominally be 1/30 seconds. The intensity-distribution of the lights must be as follows:

3.5.4.1. Steady-burning White Lights. The peak intensity for the elevated lights at the rated 120 volts must be not less than 10,000 candelas and the intensity must be not less than 1,000 candelas at any angle up to 15 degrees from the beam axis. For the in-pavement lights, the peak intensity must be not less than 5,000 candelas with the beam spread from the beam axis at 2500 candelas not less than ± 5 degrees horizontally and ± 3.5 degrees vertically and at 500 candelas not less than ± 7 degrees horizontally and ± 5.5 degrees vertically.

3.5.4.2. Sequenced Flashing Lights (SFL). The rated effective intensity must be not less than 7,500 candelas or more than 22,500 candelas for 15 degrees horizontally and 5 degrees vertically from the beam axis.

3.5.5. Aiming Criteria. Aim the beams of all approach lights into the approach zone and away from the threshold with the axis of the beams parallel in azimuth to the extended runway centerline. Aim the elevated lights vertically in accordance with table 3.2. The in-pavement lights have fixed elevation angles for the beams, and only require that the light base flange be level.

Table 3.2. Elevation Setting Angles for MALSR.

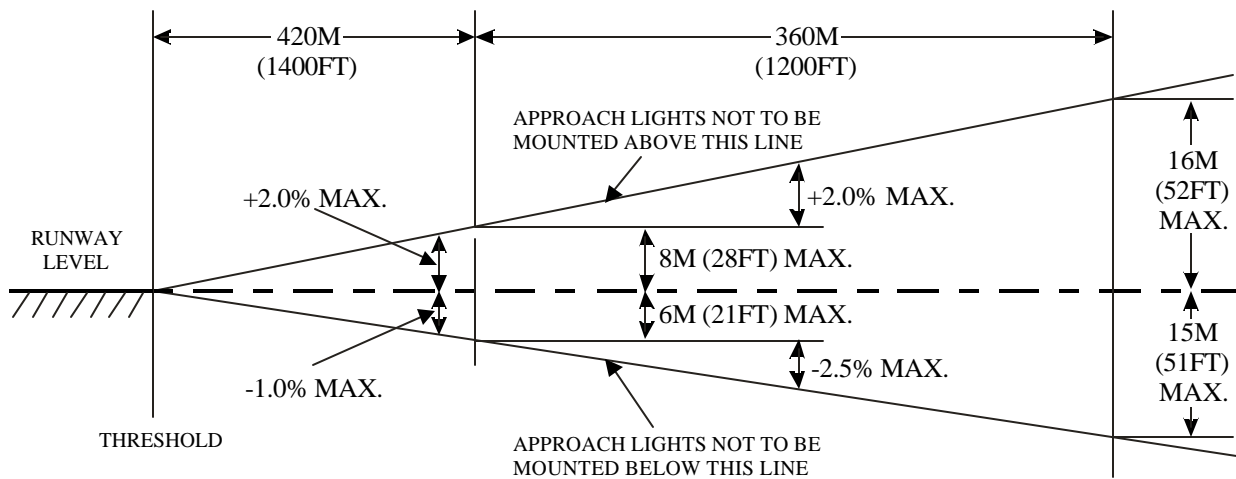
ELEVATED UNI-DIRECTIONAL LIGHTS					
Steady-Burning Lights					
Station	Setting Angle above Horizontal (Degrees)		Station	Setting Angle above Horizontal (Degrees)	
	Preferred	Permitted		Preferred	Permitted
14+00	3.7	3.5	6+00	3.4	3.5
12+00	3.6	3.5	4+00	3.3	3.5
10+00	3.5	3.5	2+00	3.2	3.0
8+00	3.4	3.5			
Elevated SFL are all aimed 6 degrees above horizontal.					

3.5.5.1. Approach Light Planes. The following restrictions apply for a MALSR installation:

3.5.5.1.1. The approach light plane (figure 3.10) is an area 120 meters (400 feet) wide centered on the extended runway centerline which begins at the runway threshold and extends 60 meters (200 feet) beyond the outermost light in which the approach light centers are located. All lines in the planes perpendicular to the runway centerline are horizontal. Ideally, all the lights will be installed in a single horizontal plane at the same elevation as the runway threshold without any penetrations by fixed solid objects. Where deviations are necessary for terrain or objects which cannot be removed, the sections starting from the first approach light station from the threshold must have a slope not exceeding +2.0 percent upward or -1.0 percent downward for the steady-burning barrette lights. For the RAIL section, the slope of the light planes must not exceed +2.0 percent or -2.5 percent. Any sloping or horizontal plane must contain not less than three light stations.

3.5.5.1.2. No object may penetrate the light plane except for ILS components and components of airfield lighting systems which are fixed by their function. These components must not interfere with the pilot's view of the approach lights when on a normal approach and must be obstruction lighted. For clearance purposes, all roads, vehicle parking areas and railroads are considered as vertical solid objects. The required clearance above railroads is 7.5 meters (23 feet) and above interstate highways is 6 meters (17 feet). The clearance required above other public roads and parking lots is 5 meters (15 feet). The clearance above private and military roads is 3 meters (10 feet). Airfield service roads, where traffic is controlled, are not considered as obstructions. Control of the service road traffic must be accomplished by appropriate signs or directly by the control tower; parking or stopping is prohibited between the signs. The Airfield Commander must approve the means of control and the wording of signs. It is preferred to get the needed clearance above a road, rather than controlling the traffic so the clearance is not necessary. Obstructions beyond the approach light system must be in accordance with UFC 3-260-01/ TM 5-803-7, *Airfield and Heliport Planning Design*.

Figure 3.10. Light Plane Elevation Limits.



NOTE: THE BOUNDARIES OF THE LIGHT PLANES ARE THE RUNWAY THRESHOLD, 60M (200FT) AHEAD OF THE END LIGHT STATION, AND 60M (200FT) EACH SIDE OF CENTERLINE.

3.5.5.1.3. Every effort must be made to remove or relocate objects which penetrate the light plane. For objects which cannot be moved, the height must keep to a minimum and must be located as far from the threshold as possible.

3.5.5.1.4. The Major Command has waiver authority to adjust the slope of the light plane beyond the allowances in this standard to avoid interference from obstacles that can not be removed or lowered..

3.5.6. Tolerance. The tolerances for positioning steady burning MALSR lights are as follows:

3.5.6.1. Lateral tolerance of a bar is 0.15 meters (6 inches).

3.5.6.2. Distance between individual light centers in a barrette is 0.05 meters (2 inches).

3.5.6.3. Height for light centers up to 1.8 meters (6 feet) is 0.05 meters (2 inches).

3.5.6.4. Height for light centers over 12 meters (40 feet) is 0.15 meters (6 inches).

3.5.6.5. Tolerance for vertical aiming of light units is 1.0 degree.

3.5.6.6. Tolerance for horizontal aiming of light unit is 5 degrees.

3.5.6.7. Longitudinal deviation for light bars or single SFL from a designated station is 6 meters (20 feet), except light stations may be displaced 30 meters (100 feet) to avoid omitting a light station where obstructions cannot be removed or cleared by acceptable clearance planes. Where a light station must be located more than 6 meters (20 feet) from the usual station, position the nearby light stations to provide more uniform spacing between lights.

3.5.7. Power Requirements. The electrical power for the MALSR approach lights must be as follows:

3.5.7.1. For the centerline and 300 meter (1,000 foot) crossbar steady-burning lights, a special power unit must furnish power to these lights from a multiple circuit rated at 120 volts or 120/240 volts 3-wire. This power unit must energize the lights at any of the three intensity settings selected.

3.5.7.2. For the SFL, the power to operate these lights is furnished by the master control unit at 120 volts. These lights have individual power supply units which may be combined with or separated from the flasher head. Allow an additional 5 KVA of transformer capacity for the SFL. **NOTE:** Emergency power is not essential for the MALSR system, but if emergency power is available, it should be used with the automatic emergency power transfer.

3.5.8. Control Requirements. The MALSR must be remotely controlled from the airfield lighting control panel in the control tower. Alternate control from the airfield lighting vault is desirable. A separate control must provide for switching ON and OFF and for selecting the intensity setting of the centerline lights, the 300 meter (1,000 foot) bar lights, and the SFL.

3.5.9. Monitoring Requirements. Automatic monitoring is not required, but must be operational if installed.

3.5.10. Equipment. See paragraphs 13.9.5 through 13.9.5.4 for typical MALSR components.

3.5.10.1. Fixtures and Components. The lighting equipment for the MALSR is shown in Chapter 13. Typical elevated steady-burning lights for the centerline lights and 300 meter (1,000 foot) bar lights are shown in the figures. Each SFL consists of a flasher head and a power supply unit. The flasher head and power supply unit may be combined to install at any distance of not more than 45 meters (150 feet) from the power supply unit.

3.5.10.2. Light Supports. The type of supports for the MALSR lights depends on the height of the light or barrette above the surface as follows:

3.5.10.2.1 Elevated light heights 2 meters (6 feet) or less use frangible supports.

3.5.10.2.2. Light heights between 2 meters (6 feet) and 13 meters (40 feet) use low-impact-resistant supports. The individual SFL or 5-light barrettes must be installed on low-impact-resistant supports of the correct height. These supports may be non-metallic, FAA-E-2702, *Low Impact Resistant Structures*, supports or triangular antenna support type, FAA AC 150/5345-45, *Lightweight Approach Light Structure*.

3.5.10.2.3. Light heights more than 12 meters (40 feet) should use semi-frangible supports. Individual SFL or 5-light barrettes must have the top 6 meters (20 feet) of the support of the low-impact-resistant type installed on a rigid support of the correct height.

3.5.10.3. Mounting the Lights. In-pavement lights should be used only in displaced threshold areas or paved overruns. These in-pavement lights must be mounted on corrosion-proof steel light bases set in a concrete foundation. These lights may project not more than 0.025 meters (1 inch) above the paved surface. The elevated lights are mounted at the correct height on frangible, low-impact-resistant, or semi-frangible supports. Frangible supports are used for heights of 2 meters (6 feet) or less. The support consists of a frangible coupling and sections of 0.05 meters (2 inch) diameter conduit elbows set in concrete foundation. For heights more than 2 meters (6 feet), the barrettes or individual SFL must be placed on low impact-resistant or semi-frangible supports.

3.5.11. Compliance with International Standards.

3.5.11.1. There are no equivalent ASCC or NATO standards for this system, however, it does meet the requirements for a Category I approach approved by the FAA.

3.6. Runway End Identifier Lights (REIL):

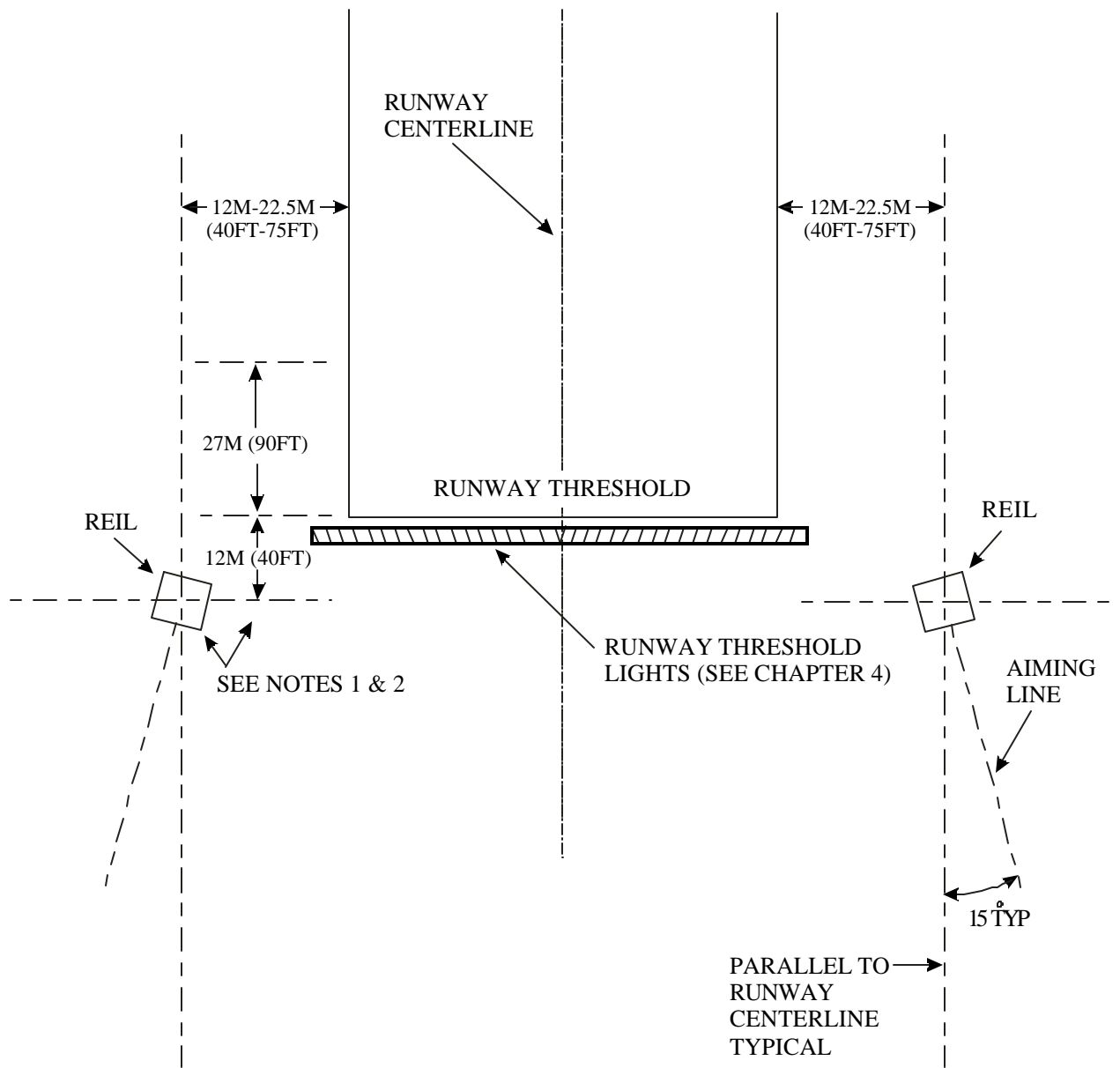
3.6.1. Purpose. The REIL provides the pilot with rapid and positive identification of the runway threshold during approach for landing. The REIL assists the pilot in making landings in VFR conditions and in non-precision instrument approaches in IFR conditions.

3.6.2. Associated Systems. The following visual aids are required with the use of the REIL: high intensity runway edge lights, runway threshold lights or displaced threshold lights, and runway markings. The PAPI system may also be an associated visual aid.

3.6.3. Configuration/Location/Aiming. A REIL system, as shown in figure 3.11, consists of synchronized flashing lights placed symmetrically about the runway centerline in the vicinity of the runway threshold. The optimum location is 12 meters (40 feet) from the runway edge and in line with the threshold lights. The lights may be located laterally up to 22.5 meters (75 feet) from the runway edge and longitudinally up to 12 meters

(40 feet) downwind (away from the runway) from the threshold lights to 27 meters (90 feet) upwind. Adjust the location of both lights as equally as possible to maintain the symmetry of the installation. The difference in locations must not be more than 3 meters (10 feet) laterally or longitudinally. The elevation of both lights must be within 3 meters (10 feet) of the runway centerline at the threshold. Do not install REILs on runways served by Pulsed Light Approach Slope Indicators (PLASI). See FAA AC 150/5340-14 for additional information.

Figure 3.11. REIL Configuration.



NOTES:

1. LONGITUDINAL LOCATION OF REIL FIXTURES MAY BE VARIED FROM IN LINE WITH THRESHOLD TO 12M (40FT) DOWNWIND AND 27M (90 FT) UPWIND OF THE THRESHOLD. BOTH FIXTURES WILL BE AT THE SAME DISTANCE.
2. UNI-DIRECTIONAL FIXTURE IS ILLUSTRATED. FOR OMNI-DIRECTIONAL FIXTURE IGNORE HORIZONTAL AIMING.

3.6.4. Photometric Requirements:

3.6.4.1. Uni-directional Fixtures. The requirements for sequenced flashing lights apply.

3.6.4.2. Omni-directional Fixtures. Omni-directional fixtures must flash at a rate of once per second, producing a white light through 360 degrees horizontally and vertically from +2 degrees to +10 degrees above the horizontal. Light units must be capable of being shielded when required by local conditions. Mount REIL fixtures on frangible supports. The unit must be capable of operating at three intensities:

Step 1 @ 700 \pm 280 cd
Step 2 @ 1,500 \pm 600 cd
Step 3 @ 5,000 \pm 2,000 cd

3.6.5. Power Requirements. The system may be powered separately or by use of a power adapter unit connected to the runway light circuit. There is no requirement for standby power.

3.6.6. Control Requirements. REIL systems may be controlled separately or coupled to the associated runway edge light circuit through current sensing relays or other devices. When coupled to the runway edge lights, they should operate as follows:

Edge Light <u>Intensity</u>	REIL <u>Intensity</u>
Off	Off
Step 1 or 2	Low
Step 3	Medium
Step 4 or 5	High

3.6.7. Monitoring Requirements. There are no monitoring requirements for the REIL system.

3.6.8. Compliance with International Standards:

3.6.8.1. NATO. The uni-directional flashing lights meet the requirements of NATO STANAG 3316 except for the displacement distance from the runway edge and the aiming angle.

3.6.8.2. ASCC. This system meets the requirements of AIR STD 90/27, except for the distance from the runway edge and the aiming angles.

3.7. Precision Approach Path Indicator (PAPI) System:

3.7.1. Purpose. The PAPI is an unattended system that provides visual glide path guidance for landing an aircraft.

3.7.1.1. Justification. For the US Army, a PAPI will be provided where one or more of the following conditions exist:

3.7.1.1.1 The runway is used by turbojet or other aircraft with similar approach guidance requirements.

3.7.1.1.2. The pilot of any type of aircraft may have difficulty judging the approach due to inadequate visual guidance that may be experienced during an approach over water or featureless terrain by day, or in the absence of sufficient extraneous lights in the approach area by night.

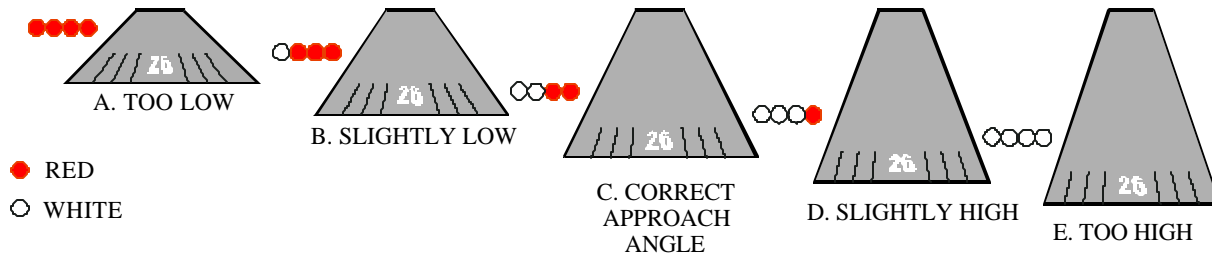
3.7.1.1.3. If judging the approach is difficult due to misleading information such as produced by deceptive surrounding terrain or runway slopes. The presence of objects in the approach area may present a serious hazard if an aircraft descends below the normal approach path, especially if there are no navigation aids to give warning of these objects.

3.7.1.1.4. Physical conditions at either end of the runway present a serious hazard in the event of an aircraft undershooting or overrunning the runway.

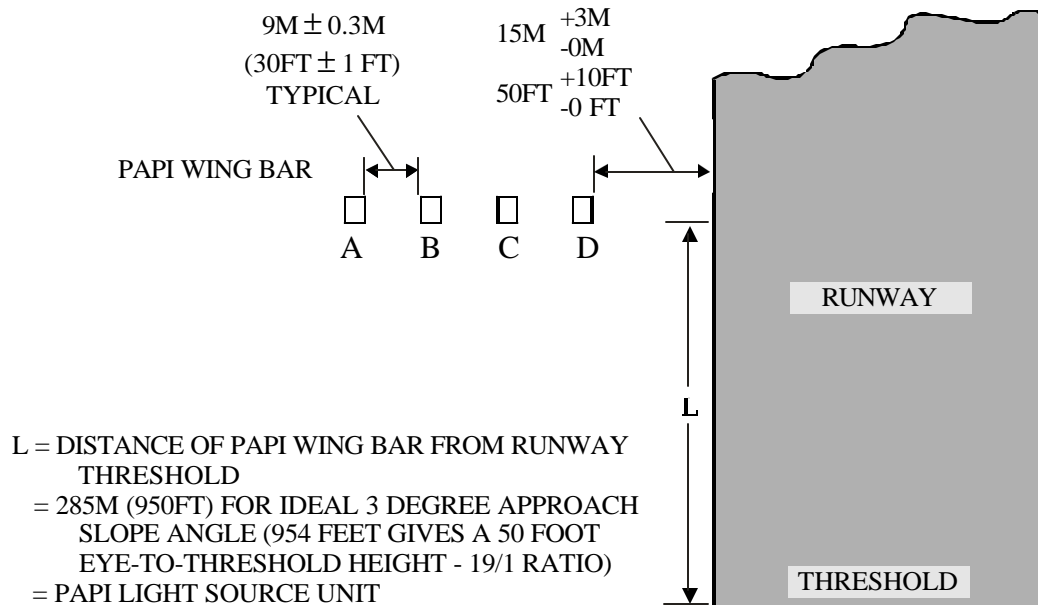
3.7.1.1.5. Terrain or prevalent meteorological conditions are such that the aircraft may be subjected to unusual turbulence during approach.

3.7.2. Configuration. The standard PAPI system consists of a light bar with four light units (FAA L-880, per AC 150/5345-28, *Precision Approach Path Indicators (PAPI) Systems*) placed on the left side of the runway in the vicinity of the touchdown point. (See figure 3.12.)

Figure 3.12. PAPI Configuration.



PAPI PATTERNS AS SEEN FROM THE APPROACH ZONE



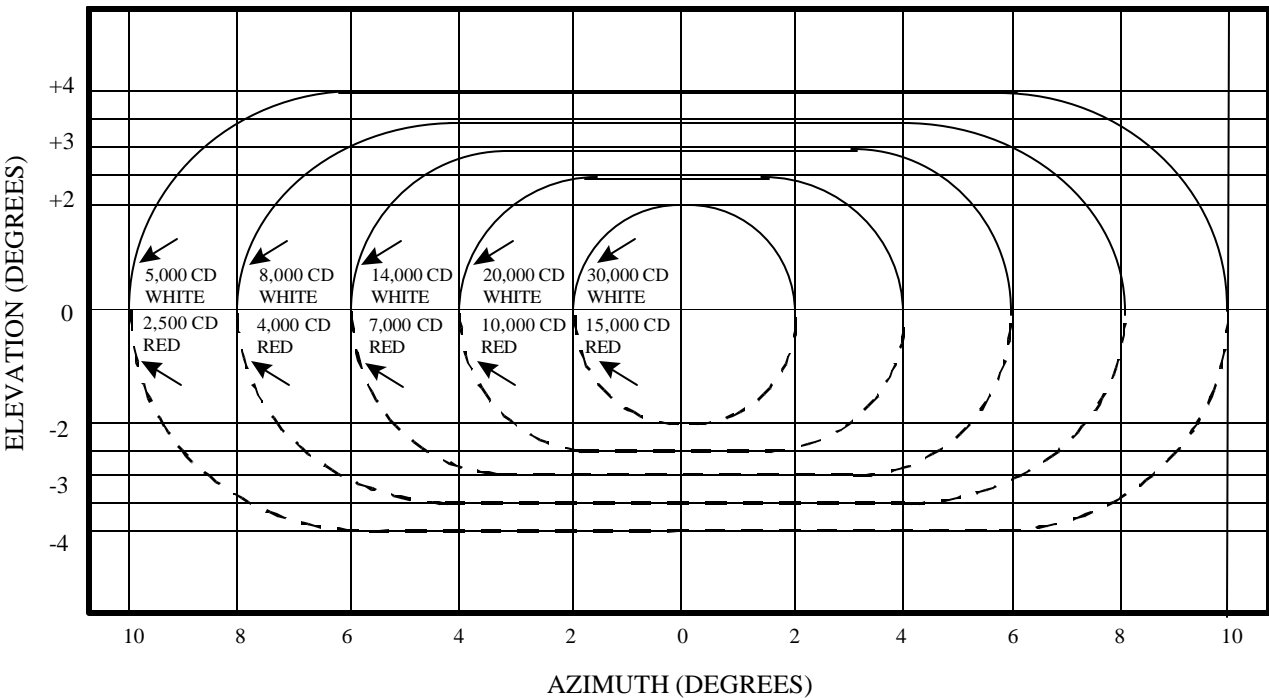
3.7.2.1. Each light unit must be frangible mounted. It must contain two lamps minimum, with 3 lamps preferred, and an optical system that produces a horizontally split, two color (white over red) light beam.

3.7.2.2. Beginning at the out-board-most units, each unit in a bar is aimed into the approach at a successively higher angle above the horizontal. When on a proper approach path, the pilot sees the two inboard lights in both bars as red and the two outboard lights as white. As the approaching aircraft settles below the proper path, the pilot sees an increasing number of red lights in each bar. As the aircraft rises above the path, the pilot sees an increasing number of white lights. (See figure 3.12.)

3.7.2.3. The edge of the innermost unit in each bar must be no closer than 15 meters (50 feet) from the runway edge, and the units in a bar must be 9 meters (30 feet) apart. The beam centers of all light units must be within ± 0.025 meters (1 inch) of a horizontal plane. This horizontal plane must be within ± 0.30 meters (1 foot) of the elevation of the runway centerline at the intercept point of the visual glidepath with the runway. The units in a bar must all be within 0.025 meters (1 inch) of a line drawn perpendicular to the runway centerline. The distance from threshold to the PAPI should be the shortest distance that will accommodate the criteria contained in paragraph 3.7.4.2.

3.7.3. Photometric Requirements. PAPI light units must be capable of satisfying the intensity requirements given in figure 3.13 at the maximum intensity setting.

Figure 3.13. PAPI Photometric Requirements.



3.7.3.1. PAPI systems must be capable of operating at five intensity settings as follows:

<u>Step</u>	<u>Percentage of Full Intensity</u>
*1	0.16
2	0.8
3	4.0
4	20.0
5	100.0

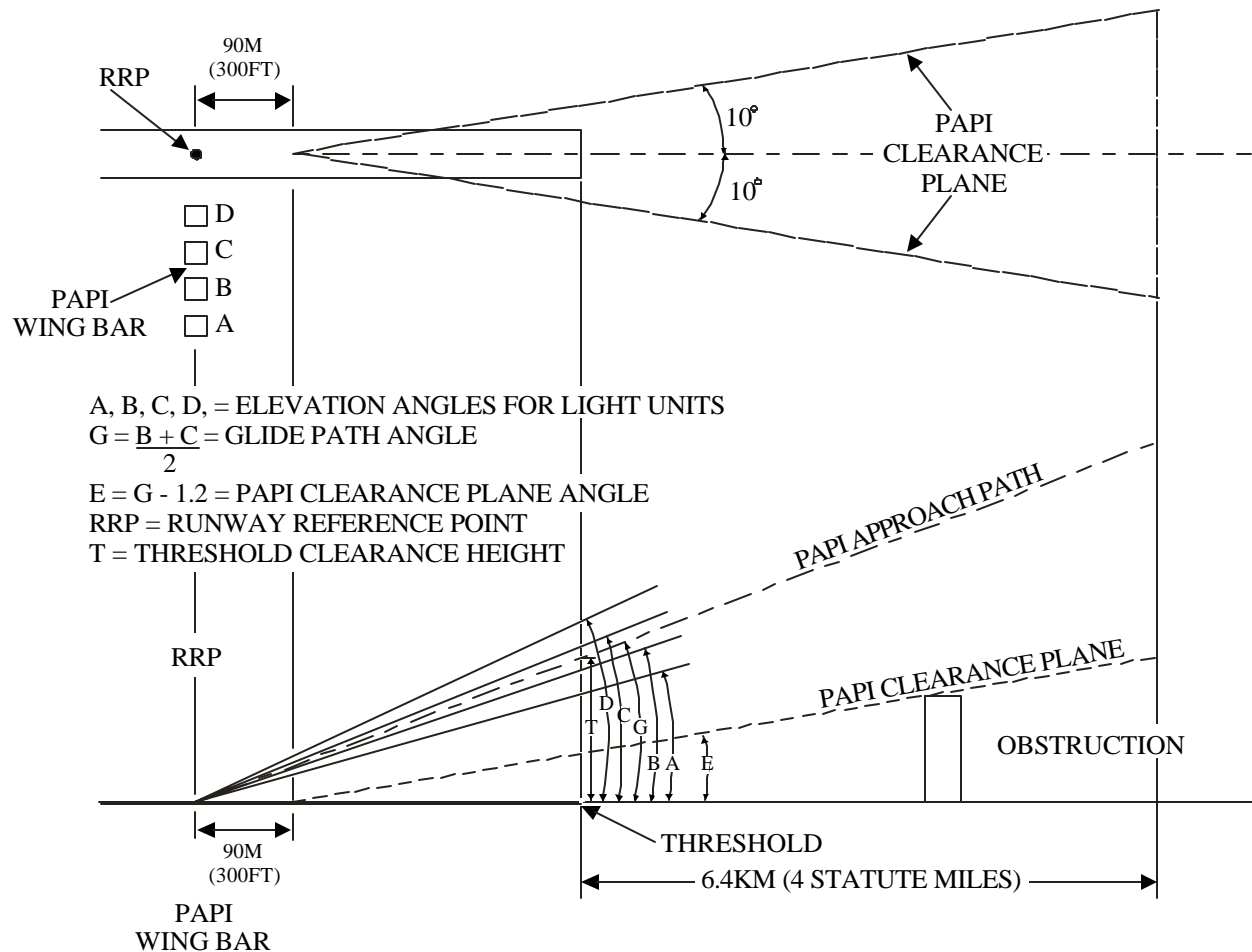
*The Step 1 setting may not be sufficient to heat the lamp filaments adequately and provide proper color definition. Where this is a problem, consult the manufacturer on how to bypass this setting.

3.7.3.2. Aim PAPI units parallel with the approach within 0.5 degrees. Aim successive light units in a light bar vertically, beginning with the out-board-most unit, and incrementally at increasingly higher angles. The

glide path angle is the mean of the highest and lowest angle setting. (See figure 3.14.) Set the angular difference between successive light units as follows:

<u>Approach Angle</u>	<u>Angular Difference</u>
2 to 4 degrees	20 minutes
over 4 to 7 degrees	30 minutes
over 7 degrees	1 degree

Figure 3.14. PAPI Aiming Criteria.



3.7.3.3. System Aiming Criteria. The location and alignment of the PAPI may be varied to meet local conditions if the effective glide path is not less than 2.5 degrees or more than 4.0 degrees above the horizontal. Unless otherwise directed or where conditions dictate otherwise, use 3.0 degrees for the design glide path angle. For design purposes, the visual glide path begins at the PAPI Runway Reference Point (RRP), which is a point on the runway centerline at the PAPI light bar (through lens center of light units) coinciding with the elevation of the lens center of the light units, and projects into the approach at the glide path angle. (See figure 3.14.) On a precision instrument runway, aim the PAPI at the same angle as the electronic glide path. For the Army only, this procedure must be modified for runways that serve aircraft in height group 4 (table 3.3); for these runways the distance of the PAPI from the threshold must equal the distance to the electronic glide slope

source plus an additional 300 feet. For the Air Force only, PAPI locating procedures will ensure a minimum safe wheel height above the threshold for all height groups using the runway.

3.7.4. Siting a PAPI must consider, as a minimum, the following: existing or planned ILS glide slope; the established glide path (aiming angle, typically 3 degrees); the threshold crossing height (TCH) for the selected aircraft height group; and the runway gradient (longitudinal slope) from the threshold to the PAPI location.

3.7.4.1. With an ILS glide slope, the PAPI is located the same distance from the runway threshold as the virtual source of the glide slope, within a tolerance of ± 10 meters (± 30 feet), and aimed at the same angle as the ILS glide slope. The virtual source is the Runway Point of Intercept (RPI), where the glide path intercepts the ground elevation along the runway centerline. For Army airfield only, this is modified for aircraft in the height group #4 (table 3.3), in which case the PAPI is sited at the RPI plus an additional 90 meters (300 feet), +15 meters –0 meters (+50 feet, -0 feet) from threshold. [See paragraph 12.3 for siting PAPI.]

Table 3.3. Visual Threshold Crossing Height Groups.

<u>Height Group</u>	<u>Approximate Cockpit-to-Wheel Height</u>	<u>Visual Threshold Crossing Height</u>
#1. Gen. Aviation, Small Commuters, Corporate Turbojets, T-37, T-38, C-21, T-1, C-12, C-20 Fighter Jets	3 M (10 ft) or less	10 M (40 ft)
#2. F-28, CV-340/440/580, B-737, DC-9, DC-8, C-9, T43, C130, B-2	4.5 M (15 ft)	12 M (45 ft)
#3. B-727/707/720/757, KC-135, C-141, C-17, B-52	6 M (20 ft)	15 M (50 ft)
#4. B747/767, L-1011, DC-10, A300, KC-10, C-5, VC-25	Over 7.5 M (25 ft)	22 M (75 ft)
Refer to FAA AC 150/5345-28 for Group 4, ILS Glide Slope-PAPI coordination and other additional information.		

3.7.4.2. Without an ILS, determine the position and aiming for the PAPI which will produce the required TCH and clearance over obstacles in the approach area. Where there is no runway gradient (zero percent grade) and other conditions are ideal, a TCH of 15 meters (50 feet) and glide path of 3 degrees yields an RRP at 291 meters (954 feet) from runway threshold. Three degrees is about a 19:1 ratio, hence every additional 1 meter (3 feet) TCH required will increase the distance of the RRP from threshold by 19 meters (62 feet). A downward runway grade or a lower glide path angle will increase the ideal distance of the RRP from threshold for the same TCH. Similarly, an upward runway gradient or a larger glide path angle will reduce the ideal distance of the RRP from threshold for the same TCH. A different TCH, based on cockpit-to-wheel height of the critical aircraft, will also change the location of the RRP, as will other conditions at the site. See paragraph 12.3 for more specific detail on siting a PAPI system, and for other siting dimensions and tolerances.

3.7.4.3. No light unit can be closer than 15 meters (50 feet) to any other runway, taxiway, or apron. Avoid locations where the system could be obscured by other installations. Do not place other lights so close to the PAPI as to cause pilot confusion. Where these conditions cannot readily be satisfied with the system located on the left side of the runway, the system with waiver approval (paragraph 1.8 or paragraph 1.9), may be sited on the right side of the runway.

3.7.4.4. Establish a PAPI clearance plane referenced to a point 90 meters (300 feet) downwind of the PAPI RRP which clears all obstructions in the approach zone. The aiming angle for the PAPI glide path must not be less than 1.2 degrees above the PAPI clearance plane. A plan view of the PAPI clearance plane is a triangle which begins at a point on the runway centerline 90 meters (300 feet) downwind from the PAPI RRP and diverges outward into the approach at 10 degrees on either side of the extended runway centerline for a distance of 6.44 kilometers (4 statute miles) from the threshold. (See figure 3.14.) Where the sides of the plane do not encompass the runway width at the threshold, the width at that point must be increased to the runway width while maintaining the 10 degree angle of divergence.

3.7.5. Power Requirements. Provide the electrical power for the PAPI system from a separate 120/240 volt circuit or a 6.6A series circuit. The 120/240 volt circuit is for parallel operation with control by photocell and selector switch at the unit. Energize the 6.6A series circuit by a constant-current regulator. A 4 kW constant current regulator, three or five intensity steps, is used to energize the PAPI on a series circuit. The number of brightness steps should match that of the runway edge lighting system. When the PAPI is required to be on a series circuit, the lights must be connected to the series circuit by series isolation transformers of suitable capacity for each lamp. Emergency power is not essential but should be used if available. The emergency transfer of power should be the same as the runway edge lights. Monitoring of the PAPI is not required except for daily visual checks of operations and periodic checks for proper aiming.

3.7.6. Control Requirements. Control the PAPI on/off manually from the air traffic control tower and from the airfield lighting vault. Brightness control will be manual, however, it may also be controlled by photocell or pilot radio control at airfields without air traffic controllers, or where the air traffic control tower is not manned full time. At these locations, provide an electrical interlock between the PAPI and the runway edge lights. This interlock may be an electrical contactor or radio interface unit to ensure that, during the hours of darkness the PAPI is only on when the runway edge lights are on. During hours of daylight, the PAPI will be capable of operating independently of the runway edge lights. PAPI on/off and intensity controls must be included on the airfield lighting control panel.

3.7.6.1. Provide radio control when required by using an FAA L-854 radio controller (see FAA AC 150/5345-49, *Specification L-854, Radio Control Equipment*), which allows the PAPI to be turned on by a pilot on approach or by a ground control station. Three clicks must provide for step 2 on a 3-step system and step 3 on a 5-step system (middle brightness step), while 5 clicks must provide for the PAPI to match the runway edge lighting brightness step at step 2 and higher. The photocell provides full intensity during daylight.

3.7.6.2. The photocell must provide for full intensity of the PAPI (highest brightness step) when the ambient lighting reaches 50-60 footcandles, and reduced brightness when the ambient lighting decreases to 25-30 footcandles (step 2 for a 3-step regulator, and step 3 for a 5-step regulator). The photoelectric control should have a time delay of at least 30 seconds to prevent false switching from stray light or temporary shadows. The photocell should be installed at an unobstructed location to aim towards the north horizon.

3.7.7. Foundations. Foundations for mounting light boxes will be made of concrete and designed to prevent frost heave or other displacement. The foundation will extend at least 0.3 meters (12 inches) below the frost line. The foundation should extend at least 0.3 meters (12 inches) beyond the light boxes to minimize damage from mowers and should not be more than 0.025 meters (1 inch) above grade. All light boxes will be frangible mounted to the foundation.

3.7.8. Equipment. See paragraph 13.9.7, for applicable PAPI system fixtures. See FAA AC 150/5345-28, latest issue, for additional information.

3.7.9. Flight Inspections. Refer to AFJMAN 11-225 (I), *United States Standard Flight Inspection Manual*, for flight inspection requirements (commissioning flight) prior to use.

3.7.10. Compliance with International Standards:

3.7.10.1. NATO. This PAPI criteria meets the requirements of NATO STANAG 3316 except the Air Force system is located on only one runway side.

3.7.10.2. ASCC. This PAPI criteria meets the requirements of ASCC AIR STD 90/27.

Chapter 4

STANDARDS FOR RUNWAY LIGHTING SYSTEMS

4.1. General Description:

4.1.1. Runway Perimeter Lighting. Runway edge lights, threshold lights, and runway end lights are used to outline the lateral and longitudinal limits of the usable surface of the runway. They are required for VFR night operation and for all categories of instrument operations.

4.1.2. Runway Surface Lighting. When Category II or III instrument operations are necessary, the perimeter lighting is augmented with touchdown zone and centerline lighting installed in the runway surface.

4.1.3. Runway Visual Aid Requirements. Tables 2.1A and 2.1B show the visual landing aids required under various conditions.

4.2. High Intensity Runway Edge Lights (HIRL):

4.2.1. Purpose. HIRLs provide visual guidance during takeoff and landing operations at night and under low visibility conditions. High intensity runway edge lights are required for Category I, II, and III instrument operations.

4.2.2. Configuration. Locate runway edge lights along the full length of the runway in two parallel rows equidistant from the centerline. Place along the edge of the area declared for use as the runway or outside the edge of the area not more than 3 meters (10 feet). (See figure 4.1.)

4.2.2.1. Light Spacing. Longitudinally, space the lights along the runway light lines at equal distances not exceeding 60 meters (200 feet). Determine the distance between lights by dividing the length of the runway light line between the threshold light lines into equal spaces approaching but not exceeding 60 meters (200 feet).

4.2.2.2. Use elevated lights in all instances except as noted in paragraph 4.2.2.3. Size the fixtures, light bases, and transformer housings to accept in-pavement fixtures in the event of future runway configuration changes or modifications where elevated fixtures may not be suitable.

4.2.2.3. Use in-pavement units in areas where elevated lights are subject to damage from jet blast, operation of an arresting system, or interference with aircraft operation. (See paragraph 13.10.1.)

4.2.3. Photometric Requirements. Optimum aiming of lights depends on the design and output of the fixtures used in the system. Light fixtures may be designed to cover several applications and may have fixed patterns and aiming angles that differ from this document. Light aiming and patterns other than those given in this document may be used if the resultant light pattern produces equivalent light intensities in the areas required by

this document. Use bi-directional high intensity runway edge lights. The lights must be white, except that the last 600 meters (2,000 feet) on an instrument runway must be yellow (caution zone indication to the pilot) with minimum intensities of the main beams (figure 4.2). They may be capable of providing small amounts of omni-directional light to provide circling guidance to the runway. The omni-directional component should be capable of being shielded during times of emergency. The main beams must be toed-in 3.5 degrees and elevated 4 degrees above the horizontal. Edge lights are operated at five intensity steps as follows:




<u>Intensity Step</u>	<u>Light Intensity Percentage</u>
1	0.16
2	0.80
3	4.00
4	20.00
5	100.00

Figure 4.1. Runway Edge Light Configuration.

NOTES:

1. ELEVATED HIRL LIGHTS ARE CONSIDERED BI-DIRECTIONAL EVEN THOUGH THEY HAVE AN OMNI-DIRECTIONAL COMPONENT.
2. LIGHTS MUST LINE UP ON OPPOSITE SIDES OF RUNWAY.

LEGEND:

- $\frac{W}{Y}$  WHITE/YELLOW LAST 2000' INSTRUMENT RUNWAY ONLY; WHITE ALWAYS FACES APPROACH DIRECTION
-  BI-DIRECTIONAL WHITE
-  SEMIFLUSH FIXTURE BI-DIRECTIONAL
- "A" EQUAL SPACING 60M (200FT) MAX.

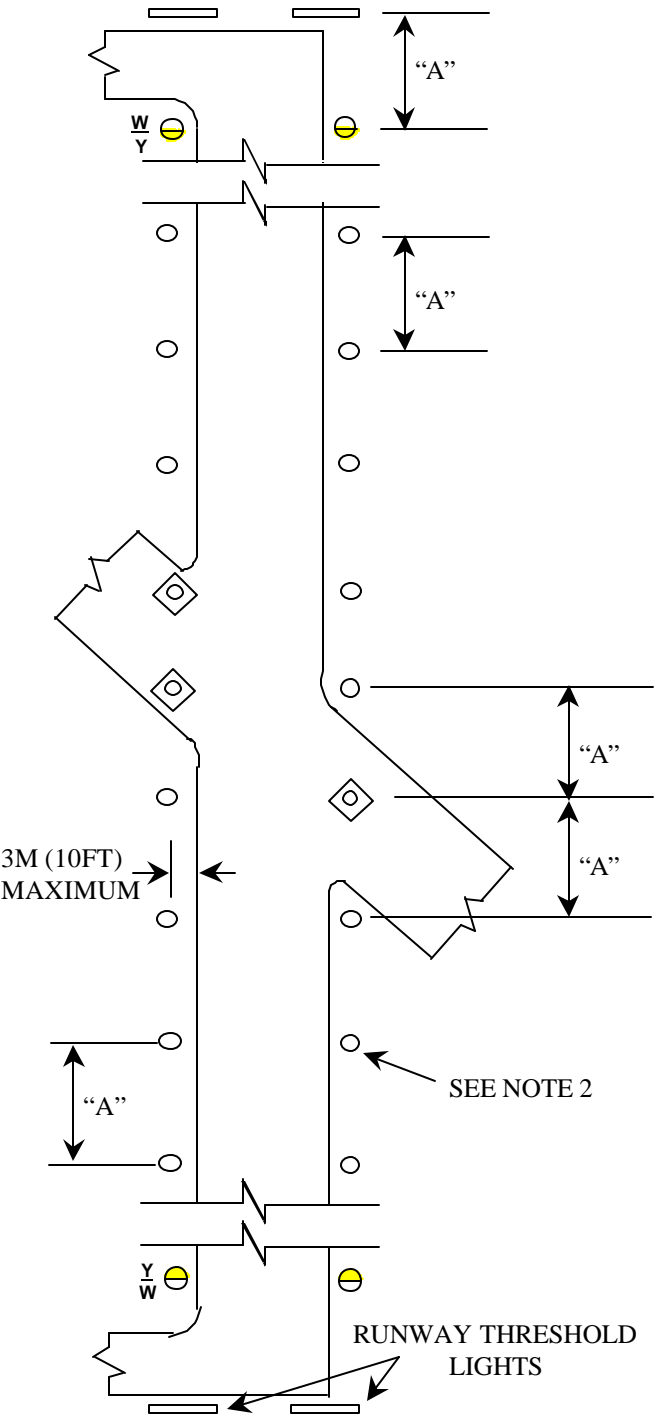
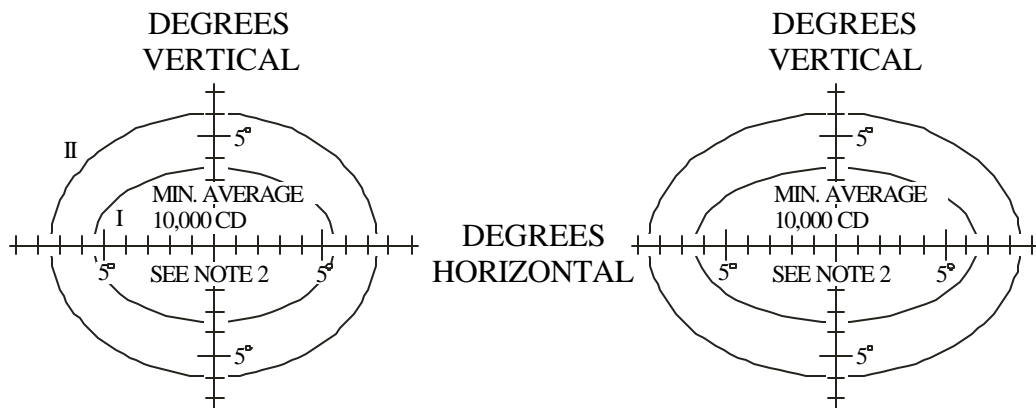


Figure 4.2. Runway Edge Light Photometric Requirements.



A. EDGE LIGHTS FOR RUNWAYS LESS THAN 60M (200FT) WIDE

	I=50%	II=10%
a	5.5°	7.5°
b	3.5°	6.0°

B. EDGE LIGHTS FOR RUNWAYS 60M (200FT) OR MORE WIDE

	I=50%	II=10%
a	6.5°	8.5°
b	3.5°	6.0°

NOTES:

1. ALL CONTOURS ARE ELLIPSES CALCULATED BY EQUATION $\frac{X^2}{a^2} + \frac{Y^2}{b^2} = 1$
2. THE MINIMUM AVERAGE INTENSITY OF THE MAIN BEAM (INSIDE CONTOUR I) IS 10,000 CD, AVIATION WHITE. MAXIMUM INTENSITY SHOULD NOT EXCEED 1.5 TIMES ACTUAL AVERAGE INTENSITY.
3. MINIMUM INTENSITY OF I=50% AND II=10% OF REQUIRED MAIN BEAM INTENSITY.

4.2.4. Equipment. Elevated fixtures must be frangible mounted at a maximum of 0.35 meters (14 inches) above grade. At locations that experience frequent snow accumulations of 0.3 meters (12 inches) or more, the mounting height may be increased to not more than 0.6 meters (24 inches) in height. No part of in-pavement fixtures must extend more than 0.025 meters (1 inch) above the surrounding surface. See paragraph 13.10.1 for applicable fixtures.

4.2.5. Power Requirements. Provide a main and a standby power system with automatic transfer. Where used in support of Category II or III instrument operations, the transfer must occur within 1 second of a failure of the system. For other operations, transfer must occur within 15 seconds of the power failure.

4.2.6. Control Requirements. When used in support of instrument operations below 730 meters (2,400 feet) RVR, provide system monitoring which, at a minimum, gives positive indication at the control facility that power is being delivered to the system.

4.2.7. Compliance with International Military Standards:

4.2.7.1. NATO. These standards meet NATO STANAG 3316.

4.2.7.2. ASCC. These standards meet the requirements of ASCC AIR STD 90/27.

4.2.7.3. See FAA AC 150/5345-46, *Specification for Runway and Taxiway Light Fixtures*, and AC 150/5340-24, *Runway and Taxiway Edge Light Systems*, for more information.

4.3. Medium Intensity Runway Edge Lights (MIRL):

4.3.1. Purpose. MIRLs are used on VFR runways, or runways having a non-precision Instrument Flight Rule procedure, for either circling or straight-in approaches. MIRLs are not installed on runways intended for precision approaches.

4.3.2. Configuration. The configuration must be as specified in paragraph 4.2.2 for high intensity runway edge lighting.

4.3.3. Photometric Requirements. Optimum aiming of lights depends on the design and output of the fixtures used in the system. Light fixtures may be designed to cover several applications and may have fixed patterns and aiming angles that differ from this document. Light aiming and patterns other than those given in this document may be used if the resultant light pattern produces equivalent light intensities in the required areas. Medium intensity runway edge lights must be omni-directional and white, except for the last 600 meters (2,000 feet) which are yellow, the lights will have minimum intensities of the main beams as follows: from +2 degrees to +10 degrees vertically, 75 candelas minimum, 125 candelas average; from +10 degrees to +15 degrees vertically, 40 candelas minimum. Where semi-flush lights are required, they may be bi-directional. The edge lights must be operated at three intensities as follows:

<u>Intensity Step</u>	<u>Percent of Full Intensity</u>
1	10%
2	30%
3	100%

4.3.4. Equipment. Elevated fixtures must be frangible mounted a maximum of 0.35 meters (14 inches) above grade. In-pavement fixtures must not protrude more than 0.025 meters (1 inch) above the surrounding surface. (See paragraph 13.10.2.) In areas of heavy snow, fixture height may be increased to a maximum of 0.6 meters (24 inches).

4.3.5. Power Requirements. Standby power is not required for medium intensity runway lights, except where they are installed on the primary runway. When installed on the primary runway, provide a main and a standby power system with automatic transfer within 15 seconds of failure of the system in use.

4.3.6. Control Requirements. Provide remote on, off, and brightness control.

4.3.7. Monitoring. There is no requirement for monitoring.

4.3.8. Compliance with International Military Standards:

4.3.8.1. ASCC. This system meets ASCC AIR STD 90/27, for lighting of non-instrument runways.

4.3.8.2. NATO. This system does not meet NATO STANAG 3316 for lighting of subsidiary runways.

4.3.9. See FAA AC 150/5345-46 and AC 150/5340-24 for more information.

4.4. Threshold Lights:

4.4.1. Purpose. Threshold lights provide positive identification of the beginning of the operational runway surface for approaching aircraft at night or under instrument weather conditions.

4.4.2. High Intensity Threshold Light Configuration. Install threshold lights in a line perpendicular to the extended runway centerline outside the usable landing area a distance of not more than 3 meters (10 feet). The line of lights is symmetrical about the runway centerline and extends 12 meters (40 feet) outboard of the

lines of runway edge lights. (See figure 4.3 for the Air Force configuration, and figure 4.4 for the Army configuration). Determine the position of the lights as follows:

Figure 4.3. Threshold Light Configuration for Air Force.

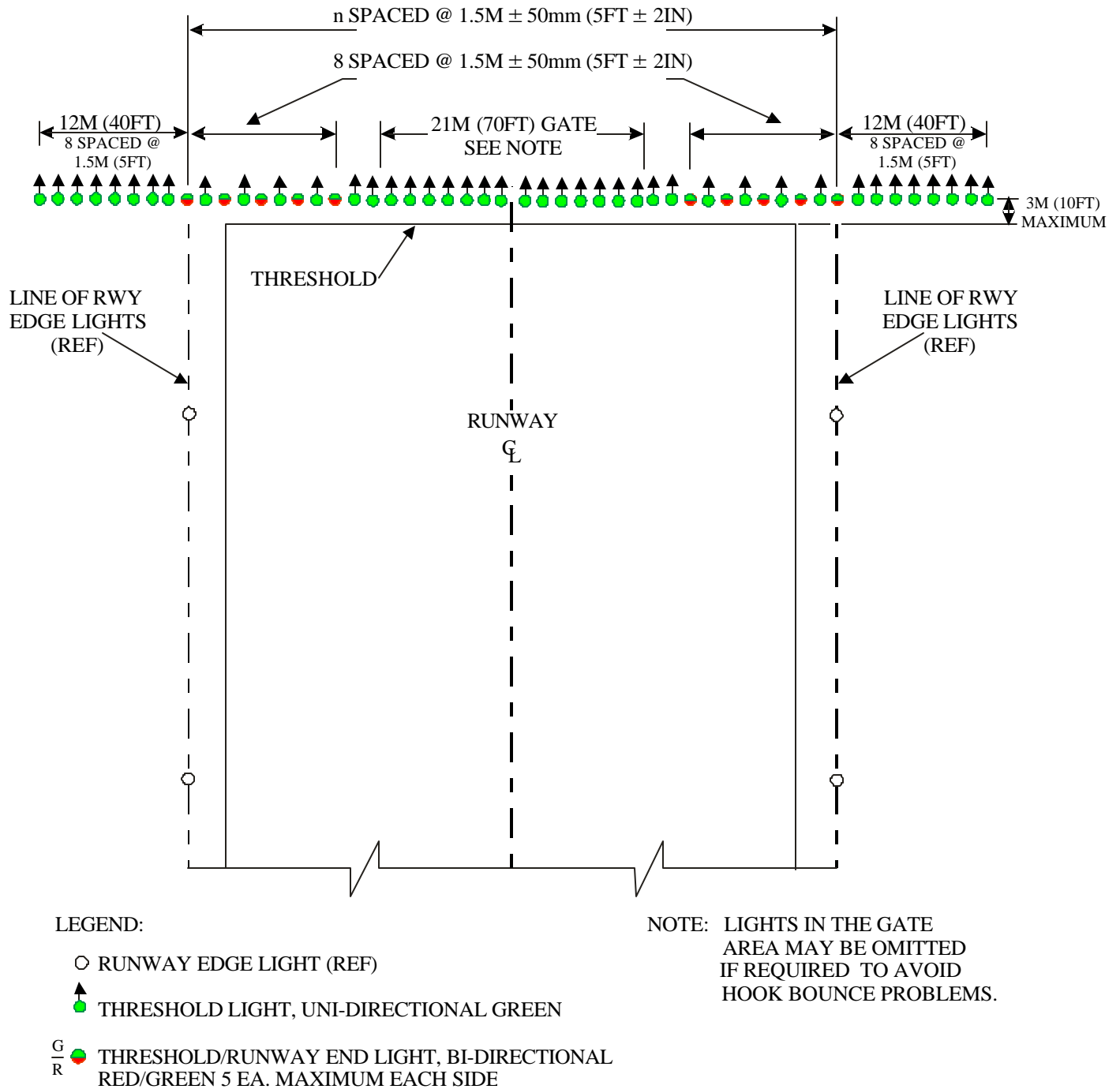
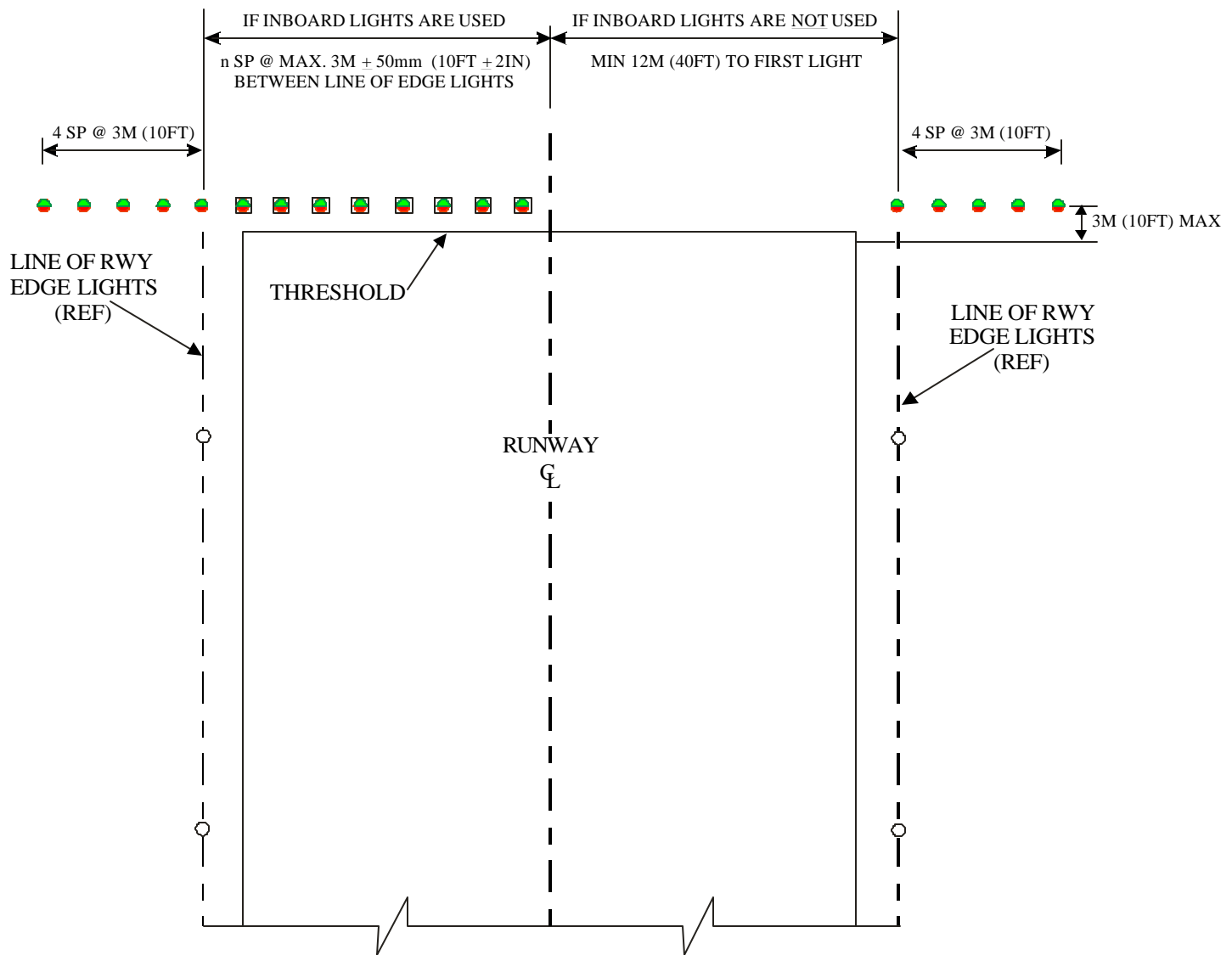


Figure 4.4. Threshold Light Configuration for Army.



LEGEND:

○ RUNWAY EDGE LIGHT (REF)

$\frac{G}{R}$  THRESHOLD/END LIGHT, SEMIFLUSH, BI-DIRECTIONAL RED/GREEN, L-852D, OPTIONAL FOR MEDIUM INTENSITY RUNWAY LIGHTING

$\frac{G}{R}$  THRESHOLD/END LIGHT, ELEVATED, BI-DIRECTIONAL, RED/GREEN, L-861SE MIN. 5 EA. EACH SIDE

4.4.2.1. Place a light where the line of threshold lights intersects the line of runway edge lights. Then place lights at 1.5 meters (5 feet) for a distance of 12 meters (40 feet) outboard of the runway edge light lines.

4.4.2.2. Place lights at uniform intervals between the lines of runway edge lights and along the line of the threshold lights. Space as near to 1.5 meters (5 feet) as possible and do not exceed 1.55 meters (5 feet 2 inches). The line of threshold lights may be gated to lessen the problem of tail hook bounce by eliminating

those lights in the center 21 meter (70 foot) portion of the threshold, but must be waived by the Major Command. Note that blank covers must be flush with the runway surface.

4.4.3. Medium Intensity Threshold Lights. Install threshold lights in a line perpendicular to the extended runway centerline outside the usable landing area a distance of not more than 3 meters (10 feet). The line of lights is symmetrical about the runway centerline and extends 12 meters (40 feet) outboard of the lines of runway edge lights. (See figure 4.4.) Determine the position of the lights as follows:

4.4.3.1. Place a light where the line of threshold lights intersects the line of runway edge lights. Next, place lights at 3 meters (10 feet) for a distance of 12 meters (40 feet) outboard of the runway edge light lines.

4.4.3.2. If inboard lights are used, place lights at uniform intervals between the lines of runway edge lights and along the line of the threshold lights. The interval must be a maximum of 3 meters (10 feet).

4.4.4. Photometric Requirements:

4.4.4.1. High Intensity Threshold Lights. Optimum aiming of lights depends on the design and output of the fixtures used in the system. Light fixtures may be designed to cover several applications and may have fixed patterns and aiming angles that differ from this document. Light aiming and patterns other than those given in the standard may be used if the resultant light pattern produces equivalent light intensities in the areas required by this standard. The lights must be uni-directional green aimed into the approach with intensities as shown in figure 4.5 when used with high intensity runway edge lights or approach lights. The light beams are aimed parallel with the runway centerline and angled upward at an angle of 4.5 degrees. High intensity threshold lights must operate at five intensity levels, together with the associated runway edge lights or approach lights when installed. High intensity runway edge lights will be used with high intensity threshold lights.

4.4.4.2. Medium Intensity Threshold Lights. The lights must be bi-directional red/green, with green aimed towards the approach. Outboard threshold elevated lights must be FAA L-861SE, and inboard threshold in-pavement lights must be FAA L-852D. See FAA AC 150/5345-46 for additional requirements.

4.4.5. Equipment. Inboard threshold lights use in-pavement fixtures with no part of the fixture protruding more than 0.025 meters (1 inch) above the surrounding surface. Outboard threshold lights use elevated fixtures, frangible mounted. Where the opposite direction runway end is collocated with the threshold, runway end lights may be incorporated into threshold light fixtures. The number of bi-directional fixtures must be the minimum required to satisfy the requirement for end light fixtures. Where traffic patterns or arresting gear equipment interfere with the use of elevated fixtures, in-pavement fixtures must be used. (See paragraph 13.10.3.)

4.4.6. Power Requirements. Power the threshold lights with the associated runway edge lights. Connect to the HIRL series circuit. Emergency and automatic transfer requirements are the same as for HIRL.

4.4.7. Control Requirements:

4.4.7.1. Where there is no approach light system, provide remote on and off and three intensity levels through the runway edge light controls.

4.4.7.2 When installing approach lights, the threshold lights may be circuited so approximately half of them are controlled by the approach light system. Interleave the threshold lights selected for operation with the approach lights, with the threshold lights to be operated with the runway lights so they present a uniform pattern symmetrical about the runway centerline when operated without runway lights. This may require that the two innermost lights be operated off the same circuit. Wherever possible, the lights selected for operation with the approach lights should not be bi-directional fixtures with runway end lights installed.

4.4.8. Aiming Threshold/ Approach. When used as part of an approach light system, bi-directional threshold lights, both in-pavement and elevated, have fixed aiming angles (with 3.5 to 4.0 degree toe-in on the red side only) for the beams and therefore cannot be adjusted.

4.4.9. Monitoring Requirements. Threshold lights have the same monitoring requirements as the edge lights.

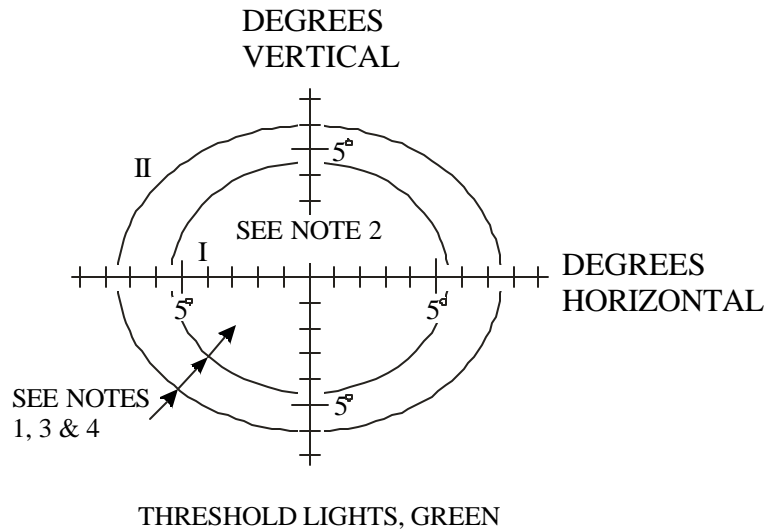
4.4.10. Compliance with International Military Standards:

4.4.10.1. NATO. The standard meets NATO STANAG 3316 for high intensity threshold lights.

4.4.10.2. ASCC. The standard meets ASCC AIR STD 90/27, for high intensity threshold lights.

4.4.11. See FAA AC 150/5345-46 for more information.

Figure 4.5. Threshold Light Photometric Requirements.



	I=50%	II=10%
a	5.5°	7.5°
b	4.5°	6.0°

NOTES:

1. ALL CONTOURS ARE ELLIPSES CALCULATED BY EQUATION $\frac{X^2}{a^2} + \frac{Y^2}{b^2} = 1$
2. THE MINIMUM AVERAGE CANDELA IN GREEN LIGHT OF THE MAIN BEAM IS 3,200 CD FOR HIGH INTENSITY SYSTEMS AND 100 CD FOR MEDIUM INTENSITY SYSTEMS.
3. MAXIMUM INTENSITY SHOULD NOT EXCEED 1.5 TIMES THE MINIMUM AVERAGE CANDELA.
4. PORTIONS OF THE LIGHT BEAM CUT OFF BY THE MOUNTING SURFACE MAY BE DISREGARDED.

4.5. Lighting with Displaced Thresholds:

4.5.1. General. The threshold, which is the beginning of the landing area, may not be located at the beginning of the full strength runway pavement. It may be displaced because of obstructions or other operational problems. The area of full strength pavement in front of the threshold may be required for takeoff or for rollout on landings from the opposite direction. Where this occurs, changes to the standards for runway lighting are required.

4.5.2. Configuration for Permanent Displacement. See figures 4.6 and 4.7 for typical layouts of displaced thresholds.

4.5.2.1. Install threshold lights, as specified in paragraph 4.4, with dimensions referenced to the theoretical beginning of the usable landing area.

4.5.2.2. Install runway end lights, as specified in paragraph 4.6 with measurements referenced from the end of the usable takeoff and rollout area.

4.5.2.3. When the displaced runway area is used for specific operations (takeoff, rollout, taxiing) appropriate edge lights for the function are installed to delineate the outline.

4.5.2.4. The runway centerline lights facing the approach direction in the displaced area must be blanked out if the length of the displacement is less than 210 meters (700 feet). If the displacement is 210 meters (700 feet) or greater, circuit the centerline lights in the area separately. Provide the capability to turn runway centerline lights off during landing operations. If a high intensity approach light system is installed, this switching capability is not required.

4.5.2.5. Install approach lights and visual approach slope indicators, such as PAPI, as specified in this standard using the theoretical beginning of the usable landing area (threshold) as the reference. Ensure coordination has been performed for relocation of any instrument approach aids.

4.5.2.6. Where the abandoned runway surface is not used for aircraft movement, the threshold lighting is relocated to the new threshold location. Lights in or along the abandoned surface are not required.

4.5.3. Configuration for Temporary Displacement. See figure 4.8 for a typical layout of temporary displaced threshold with construction or obstructions on the approach end. See figure 4.9 for layout when threshold/end of runway lights are co-located. Where the threshold is temporarily displaced and the duration of the displacement is insufficient to warrant the relocation of all facilities (normally 6 months or less), the following applies:

4.5.3.1. Coordinate with Terminal Instrument Procedures Specialist (TERPS) or FAA equivalent, airfield manager, CE Community planner, safety, and standardization and evaluation office to determine placement of the threshold.

4.5.3.1.1. Include temporary displaced threshold layout and configuration in the construction phasing plan and submit temporary displaced threshold requirement/configuration as a part of the temporary waiver request to the installation commander for a construction project within the airfield environment.

4.5.3.2. Disable the permanent threshold, runway end lights, approach lighting system, visual glide slope indicating systems such as PAPI or VASI, and any touchdown zone lights serving that end of the runway.

4.5.3.3. Install temporary threshold lights, as specified in figures 4.8 or 4.9, with dimensions referenced to the theoretical beginning of the usable landing area. Additional lights may be added for a 90 meter (300 foot) wide runway.

4.5.3.4. Install temporary runway end lights, as specified in paragraph 4.6, with dimensions referenced from the end of the usable takeoff and rollout area. **NOTE:** When temporary displacement is due to construction work, place the runway end lights to allow an additional 1,000 feet for emergency roll-out or to protect the Approach-Departure Clearance Surface from the tallest equipment that will be erected in the approach-departure zone. See UFC 3-260-01 for geometric requirements of the Approach-Departure Clearance Surface.

4.5.3.5. All fixtures are elevated and may be stake mounted or mounted on planks fastened to the runway surface.

4.5.3.6. Cables and transformers may be laid on the surface but must be protected from damage.

4.5.3.7. Modify runway edge lights in the temporary displaced area to show red light toward the approach direction (see figures 4.8 and 4.9). (When the displaced area is intended to be used for rollout or taxiing operations, the color of the edge lights must be modified with red toward approach and white toward the runway.) See paragraph 4.2.3 for photometric requirements on instrument runways.

Figure 4.6. Displaced Threshold Light Configuration (Permanent) Where Runway Surface is Used for Take-off and Rollout of Aircraft.

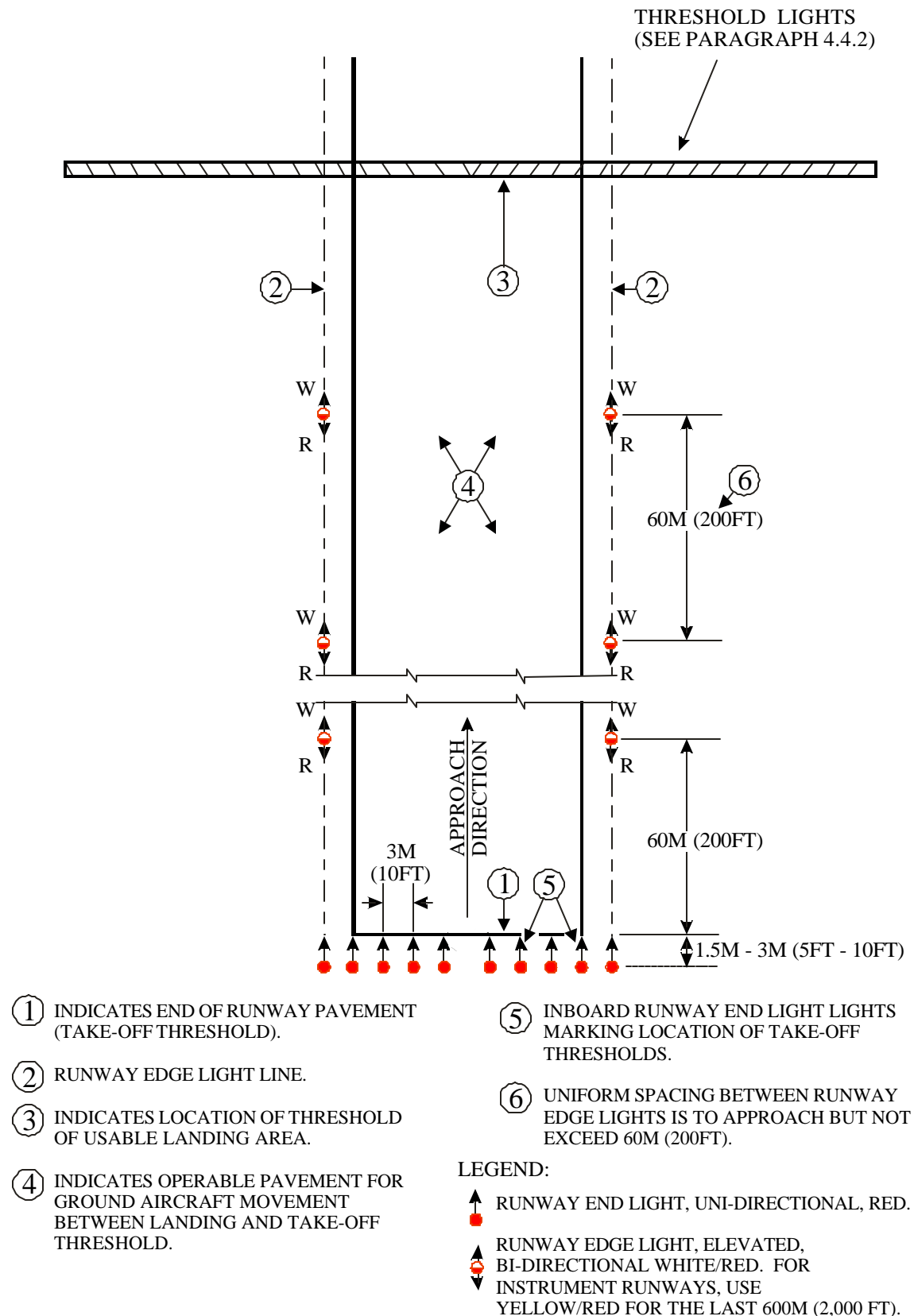
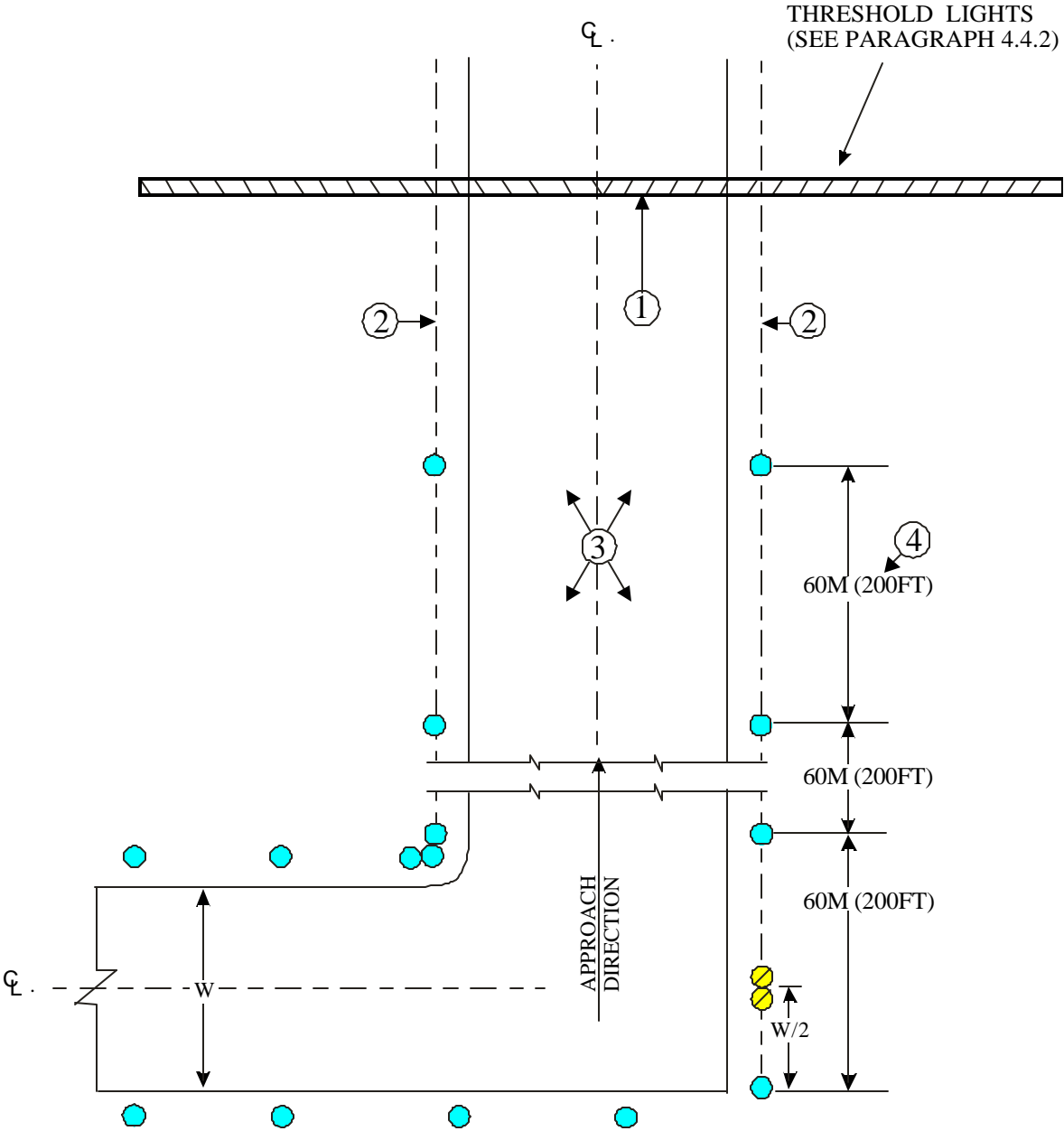


Figure 4.7. Displaced Threshold Light Configuration (Permanent) Where Runway Surface is Used as a Taxiway.



- ① INDICATES END OF RUNWAY PAVEMENT AND LOCATION OF DISPLACED THRESHOLD.
- ② TAXIWAY EDGE LIGHT LINE.
- ③ INDICATES OPERABLE PAVEMENT FOR TAXIWAY AIRCRAFT MOVEMENT.
- ④ UNIFORM SPACING BETWEEN TAXIWAY EDGE LIGHTS IS TO APPROACH BUT NOT EXCEED 60M (200FT).

- LEGEND:
- TAXIWAY EDGE LIGHT, BLUE.
 - TAXIWAY END LIGHTS, YELLOW, LOCATE ON EXTENDED CL.

4.5.3.8. Runway centerline lights in the displaced area will be blanked toward the approach direction and red toward the runway opposite the approach.

4.5.3.9. Runway Distance Markers (RDM) number panels facing toward the opposite end approach must be blanked or temporarily replaced with the new number panels reflecting the shorter distance to go. Renumbering is done so that at least 300 meters (1,000 feet) remain between the last number (#1) and the displaced runway end.

Figure 4.8. Displaced Threshold Lighting (Temporary).

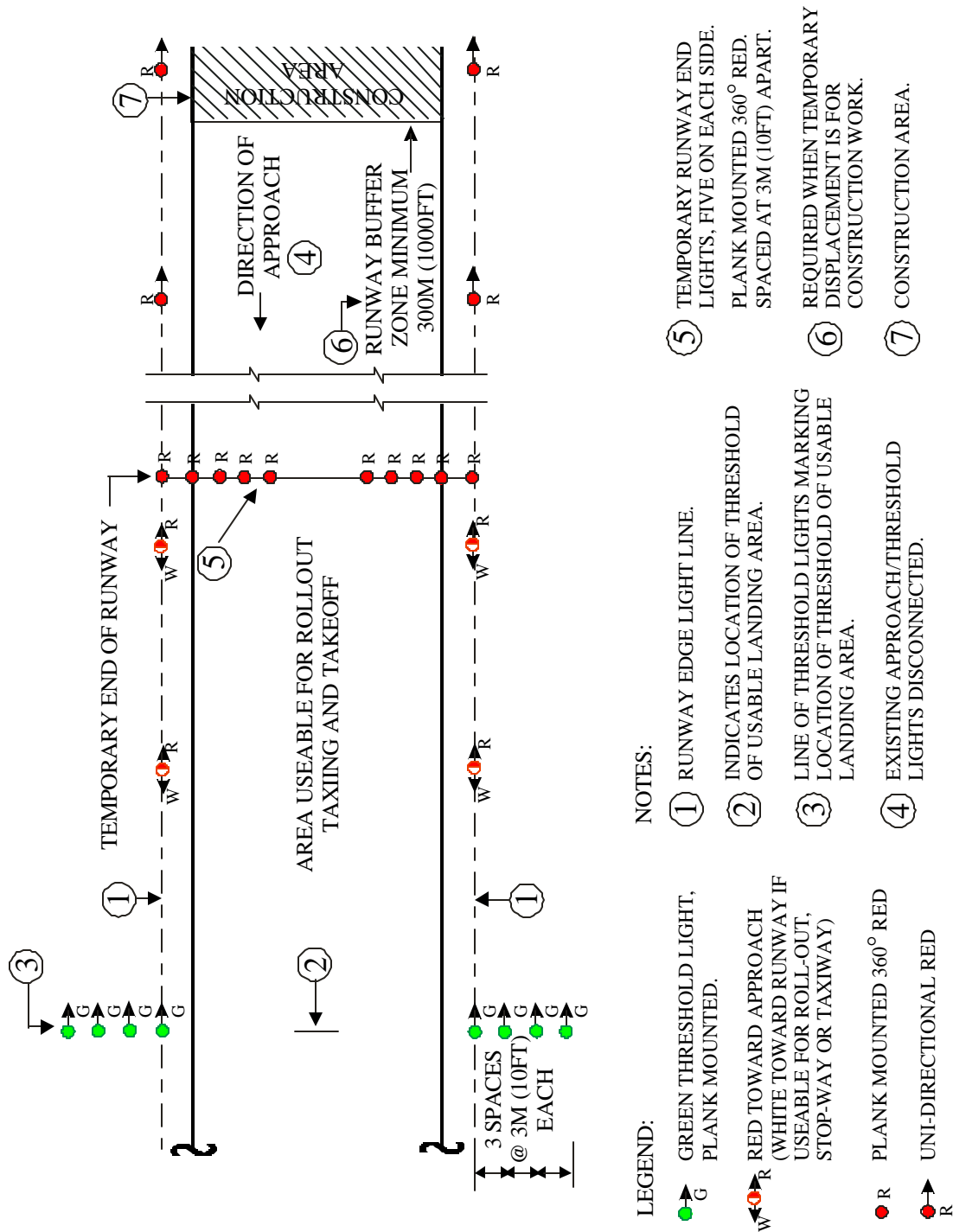
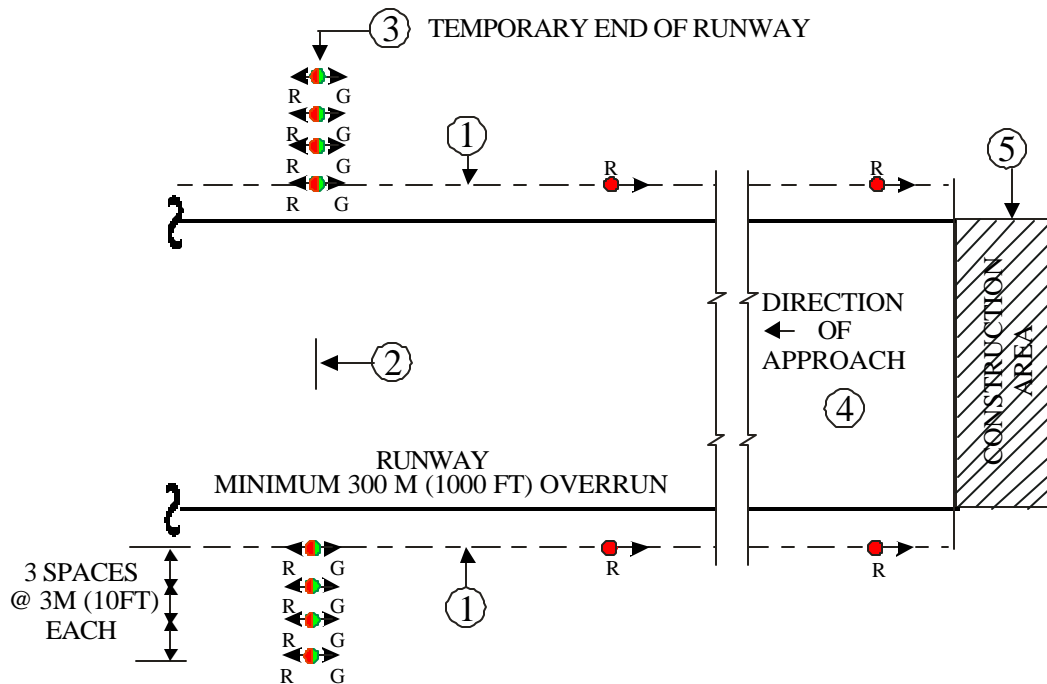




Figure 4.9. Displaced Threshold Lighting with Co-located Threshold/End of Runway Lights (Temporary).



LEGEND:

-  THRESHOLD LIGHT, PLANK MOUNTED. BI-DIRECTIONAL RED/GREEN.
-  RED TOWARD APPROACH (WHITE TOWARD RUNWAY IF USEABLE FOR ROLL-OUT, STOP-WAY OR TAXIWAY)

NOTES:

- ① RUNWAY EDGE LIGHT LINE.
- ② INDICATES LOCATION OF THRESHOLD OF USABLE LANDING AREA.
- ③ LINE OF THRESHOLD LIGHTS MARKING LOCATION OF THRESHOLD OF USABLE LANDING AREA. TEMPORARY END OF RUNWAY.
- ④ EXISTING APPROACH/THRESHOLD LIGHTS DISCONNECTED.
- ⑤ CONSTRUCTION AREA.

4.5.4. Equipment. See paragraph 13.10.3.

4.5.5. Power, Control and Monitoring. (See paragraph 4.4.)

4.5.6. Compliance with International Standards.

4.5.6.1. NATO. Same as paragraph 4.4.

4.5.6.2. ASCC. Same as paragraph 4.4.

4.5.7. See FAA AC 150/5345-46 for more information.

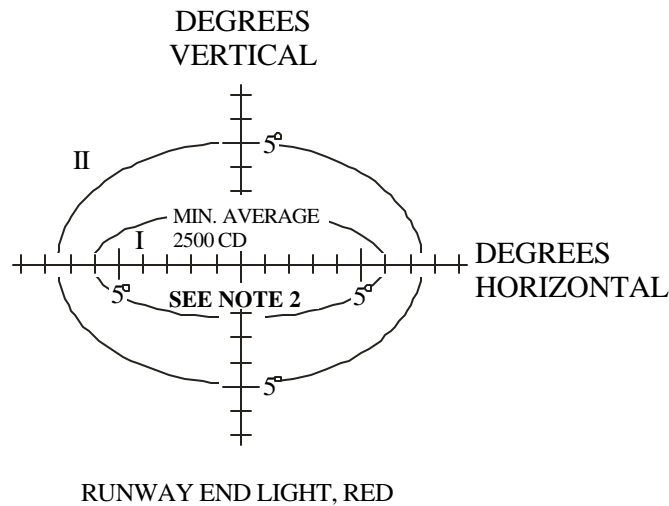
4.6. Runway End Lights:

4.6.1. Purpose. Runway end lights define the end of the operational runway surface for aircraft for landing, rollout or takeoff. They are required on all lighted operational runways.

4.6.2. Configuration. Runway end lights consist of 10 red lights in two groups of 5 lights. Place the groups symmetrically and on a line perpendicular to, the runway centerline within 3 meters (10 feet) of the end of the usable runway surface. The lights in each group must have a uniform spacing between 3 meters (10 feet) and 4.5 meters (15 feet). The out-board-most light in each group must be in line with the line of the runway edge lights on that side of the runway. Runway end lights are usually co-located with the opposite end threshold lights. Where they are co-located, runway end lights may be incorporated into the opposite end threshold fixtures provided the photometric requirements are met. (See figure 4.3 for the Air Force configuration, and figure 4.4 for the Army configuration). When runway width exceeds 45 meters (150 feet) additional runway end lights may be added.

4.6.3. Photometric Requirements. Optimum aiming of lights depends on the design and output of the fixtures used in the system. Light fixtures may be designed to cover several applications and may have fixed patterns and aiming angles that differ from this document. Light aiming and patterns other than those in the standard may be used if the resultant light pattern produces equivalent light intensities in the areas required by this standard. Use uni-directional red runway end lights facing toward the runway. When used with HIRL, they must meet the intensity requirements shown in figure 4.10. Aim the lights parallel with the runway centerline and upward at 3 degrees above the horizontal. They must operate at five intensities as specified in paragraph 4.2.3 for HIRL. Runway end lights used with MIRL must have reduced intensities compatible with the edge lights and operate at three intensity steps.

Figure 4.10. Runway End Light Photometrics.



	I=50%	II=10%
a	6.0°	7.5°
b	2.25°	5.0°

NOTES:

1. ALL CONTOURS ARE ELLIPSES CALCULATED BY EQUATION $\frac{X^2}{a^2} + \frac{Y^2}{b^2} = 1$
2. THE MINIMUM AVERAGE INTENSITY OF THE MAIN BEAM (INSIDE CONTOUR I) IS 2,500 CD, AVIATION RED. MAXIMUM INTENSITY SHOULD NOT EXCEED 1.5 TIMES ACTUAL AVERAGE INTENSITY.
3. MINIMUM INTENSITY OF I=50% AND II=10% OF REQUIRED MAIN BEAM INTENSITY.

4.6.4. Equipment. Unless the lights are to be located in an area not paved, use in-pavement fixtures with no part protruding more than 0.025 meters (1 inch) above the surrounding surface. Where the runway end is co-located with the opposite direction threshold, the threshold and runway end lights may not be incorporated into the same fixture unless the photometrics meet the requirements for both the red and green colors. (See paragraph 13.10.4.)

4.6.5. Compliance with International Military Standards:

4.6.5.1. NATO. These standards meet NATO STANAG 3316.

4.6.5.2. ASCC. These standards meet ASCC AIR STD 90/27, for runway end lights.

4.6.6. See FAA AC 150/5345-46 for more information.

4.7. Runway Centerline Lights (RCL):

4.7.1. Purpose. The runway centerline lights provide lateral guidance during landing, rollout and takeoff roll under low visibility conditions. They are required for Categories II and III instrument operations.

4.7.2. Configuration. The runway centerline lighting system is a straight line of lights which runs parallel with and within 0.6 meters (2 feet) of the runway centerline. Configure the system as shown in figure 4.11. The lighting system extends from 22.5 meters (75 feet) of the upwind end of the runway. It is desirable to offset centerline light fixtures on runways equipped with aircraft arresting systems to avoid hook-skip problems and damage to the centerline light fixtures. Up to three fixtures may be omitted in the vicinity of the arresting gear pendant cables to avoid hook bounce and minimize light damage. Existing centerline light fixtures within this area should be removed and replaced with blank cover plates. (See paragraph 13.10.6.)

4.7.3. Photometric Requirements. Optimum aiming of lights depends on the design and output of the fixtures used in the system. Light fixtures may be designed to cover several applications and may have fixed patterns and aiming angles which differ from the standard. Light aiming and patterns other than those given in the standard may be used if the resultant light pattern produces equivalent light intensities in the areas required by the standard. The centerline lights must be bi-directional and emit white light. They must be color coded on the final 900 meters (3,000 feet) portion. (See figure 4.12.) The lights must meet the intensity requirements shown in figure 4.10. They must be aimed parallel with the runway centerline and upward at 4.5 degrees. They must operate at 5 intensity steps as specified in paragraph 4.2 for runway edge lights.

4.7.4. Adjustment and Tolerances. The line of lights may be offset a maximum of 0.6 meters (2 feet) from the runway centerline to avoid interference with construction joints. Installation tolerance for fixtures is ± 0.025 meters (1 inch) from the design location. The mounting surface of the fixture must be level within 1 degree in any direction and the horizontal must be within 1 degree of that specified.

4.7.5. Equipment. Use in-pavement fixtures with no part protruding more than 0.01 meters (0.5 inch) above the surrounding surface.

4.7.6. Power Requirements. For Categories II and III operations, provide a main and standby power system with automatic transfer within one second of a failure of the system. For Category I operation, a 15 second transfer is adequate.

4.7.7. Control Requirements. Provide remote on-off and intensity control.

4.7.8. Monitoring Requirements. When supporting of operations below 720 meters (2,400 feet) RVR, provide system monitoring which, at a minimum, gives positive indication at the control facility that power is being delivered to the lights.

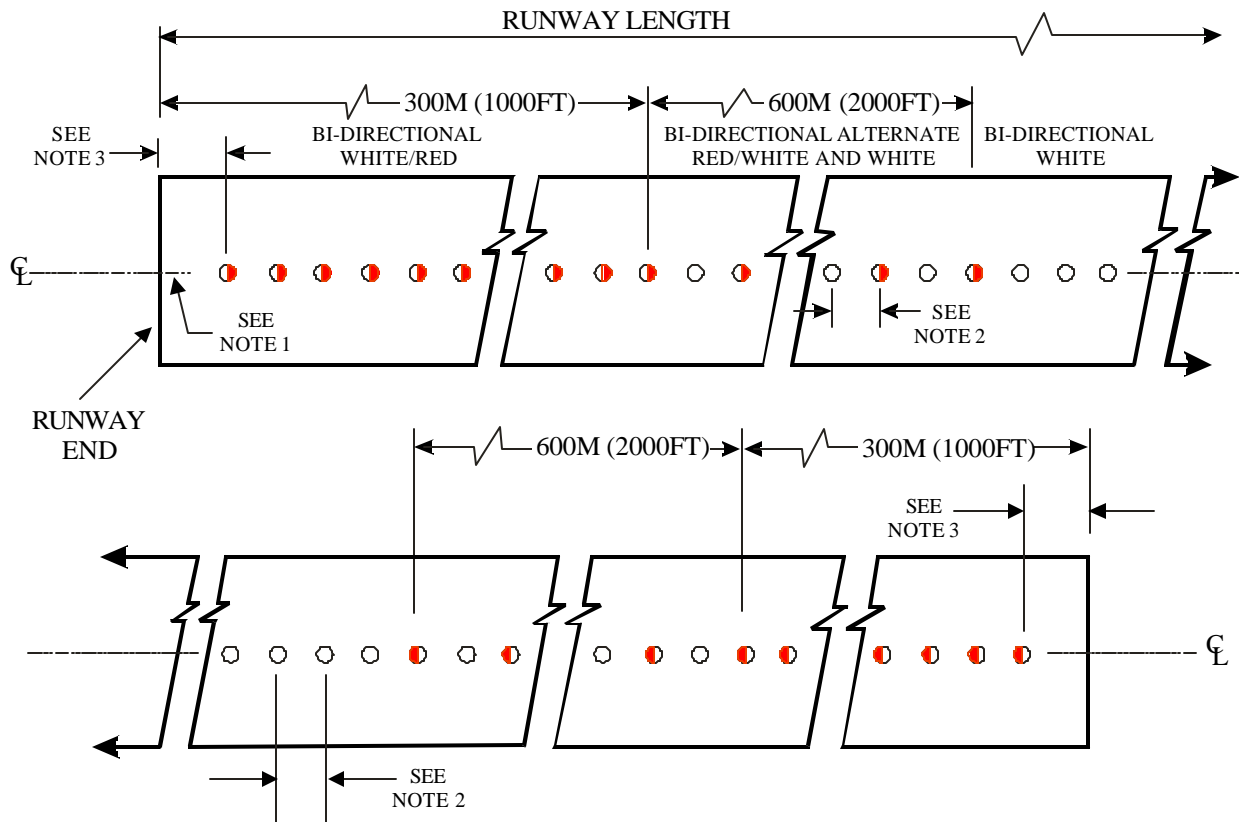
4.7.9. Compliance with International Military Standards:

4.7.9.1. ASCC. These standards meet the requirements of AIR STD 90/27, for Category II conditions.

4.7.9.2. NATO. These standards meet the NATO STANAG 3316.

4.7.9.3. See FAA AC 150/5340-4, *Installation Details for Runway Centerline Touchdown Zone Lighting Systems*, for more information.

Figure 4.11. Runway Centerline Light Configuration.



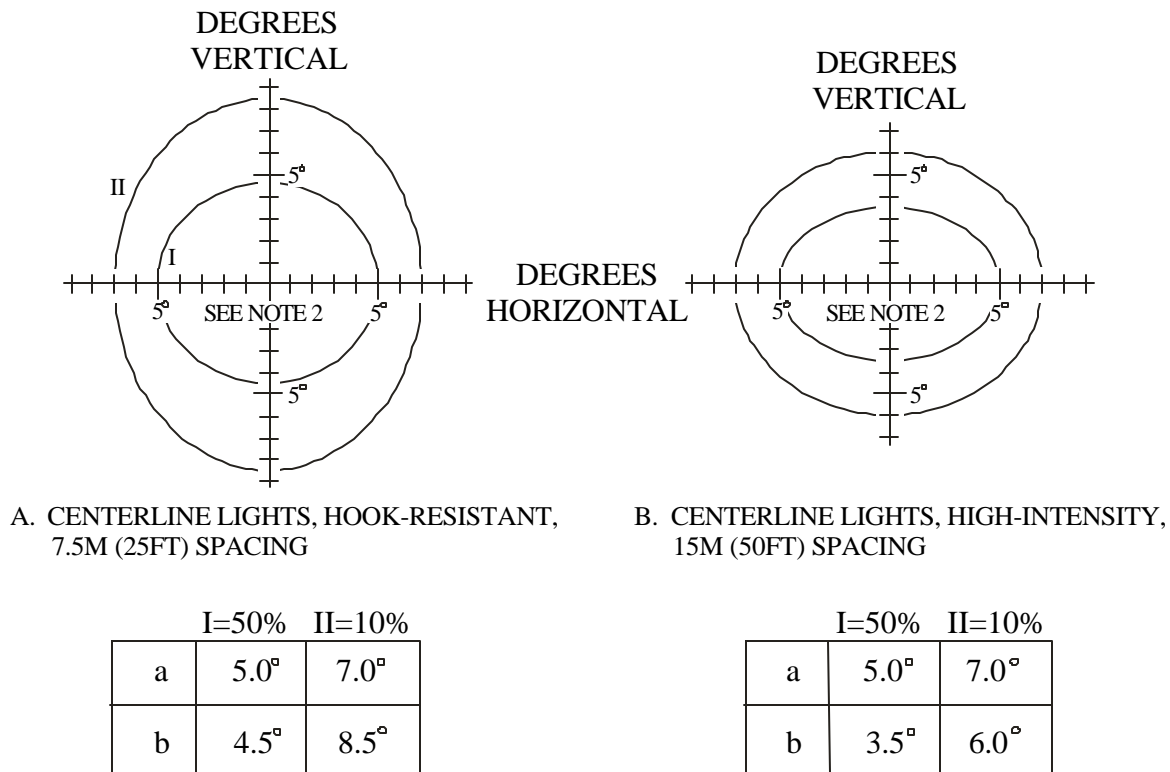
NOTES:

1. THE RCL LINE MAY BE OFFSET NOT MORE THAN 0.6M (2FT) RIGHT OR LEFT OF THE RUNWAY CENTERLINE. THE LATERAL TOLERANCE FROM THE LINE OF LIGHTS $\pm 25\text{mm}$ (1 IN).
2. THE RCL MUST BE EQUALLY SPACED AT 15M (50FT) FOR FAA TYPE L-850A LIGHTS. THE LONGITUDINAL TOLERANCE IS $\pm 0.6\text{M}$ (2FT).
3. THE FIRST LIGHT FROM EITHER END OF THE RUNWAY MUST BE FOR FAA TYPE L-850A LIGHTS NOT LESS THAN 15M (50FT) AND NOT MORE THAN 26.7M (87.5FT).

LEGEND:

- BI-DIRECTIONAL RCL - WHITE BOTH DIRECTIONS
- ◐ BI-DIRECTIONAL RCL - RED IN DIRECTION OF SHADED SIDE, WHITE IN DIRECTION OF WHITE SIDE

Figure 4.12. Runway Centerline Light Photometric Configuration.



NOTES:

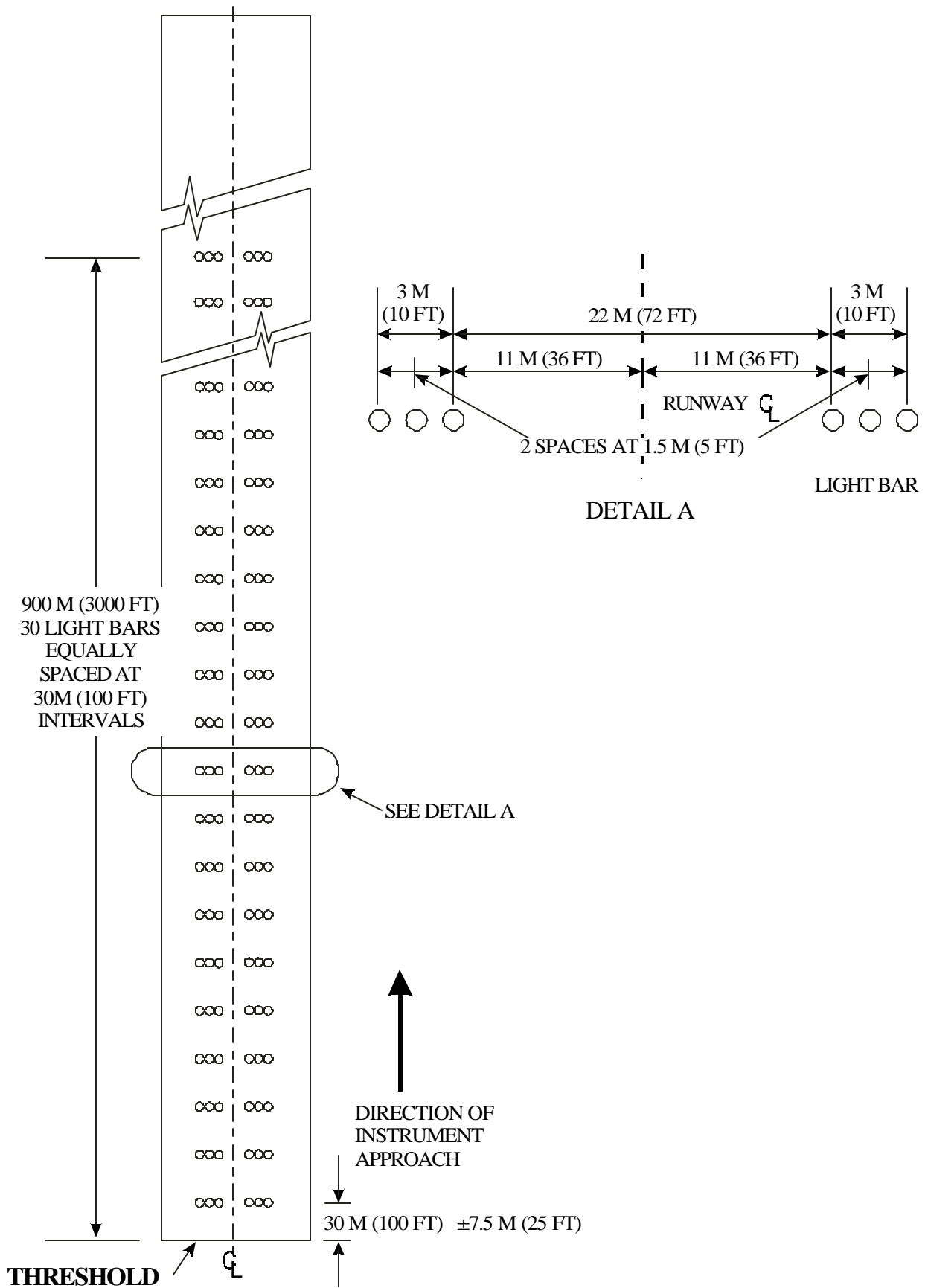
1. ALL CONTOURS ARE ELLIPSES CALCULATED BY EQUATION $\frac{X^2}{a^2} + \frac{Y^2}{b^2} = 1$
2. THE MINIMUM AVERAGE INTENSITY OF THE MAIN BEAM (INSIDE CONTOUR I) IS FOR 7.5M (25FT) SPACING, 250 CD (WHITE) AND 250 CD (RED); AND FOR 15M (50FT) SPACING 5000 CD AND 750 CD (RED). MAXIMUM INTENSITY SHOULD NOT EXCEED 1.5 TIMES ACTUAL AVERAGE INTENSITY.
3. MINIMUM INTENSITY OF I=50% AND II=10% OF REQUIRED MAIN BEAM INTENSITY.

4.8. Touchdown Zone Lights (TDZL):

4.8.1. Purpose. Touchdown zone lights provide continuity when crossing the threshold into the touchdown area and provide visual cues during the flare out and touchdown phases of the landing. They are required for Category II or III operations.

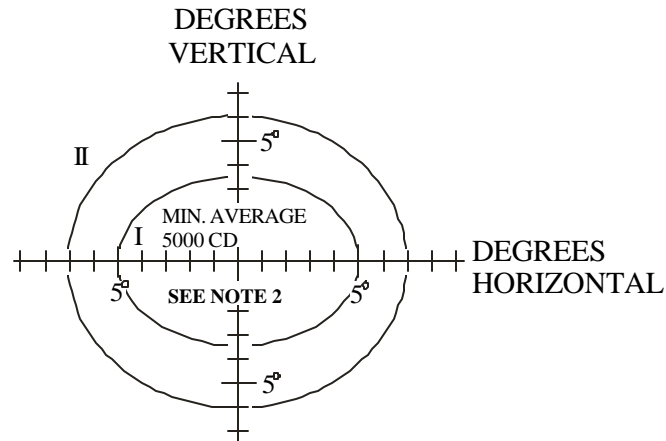
4.8.2. Configuration. The touchdown zone lighting system presents, in plain view, two rows of high intensity light bars arranged symmetrically about the centerline of the runway. The two rows of light bars are located within the paved area of the runway in order to define that portion of the landing area used for flare and touchdown. The system extends from the threshold of the usable landing area toward the upwind end of the runway, a distance of 900 meters (3,000 feet). The light bars are in rows at 30 meter (100 foot) intervals. Each light bar contains three lights spaced at 1.5 meters (5 feet) on center with the inboard light located 11 meters (36 feet) from the runway centerline. (See figure 4.13.)

Figure 4.13. Touchdown Zone Light Configuration.



4.8.3. Photometric Requirements. Optimum aiming of the lights depends on the design and layout of the fixtures used in the system. The light fixtures may be designed to cover several applications and may have fixed patterns and aiming angles which differ from this document. The light aiming and patterns other than those cited in this standard may be used if the resultant light pattern produces equivalent light intensities in the areas regulated by the standard. TDZ lights must emit uni-directional aviation white light with intensities as shown in figure 4.14. They must be toed in 4 degrees toward the centerline and aimed upward 5.5 degrees. The lights must operate at five intensity steps as specified in paragraph 4.2 for HIRL.

Figure 4.14. Touchdown Zone Light Photometric Requirements.



TOUCHDOWN ZONE LIGHTS, WHITE

	I=50%	II=10%
a	5.0°	7.0°
b	3.5°	6.0°

NOTES:

1. ALL CONTOURS ARE ELLIPSES CALCULATED BY EQUATION $\frac{X^2}{a^2} + \frac{Y^2}{b^2} = 1$
2. THE MINIMUM AVERAGE INTENSITY OF THE MAIN BEAM (INSIDE CONTOUR I) IS 5,000 CD AVIATION WHITE. MAXIMUM INTENSITY SHOULD NOT EXCEED 1.5 TIMES ACTUAL AVERAGE INTENSITY.
3. CONTOURS I=50% AND II=10% INDICATE THE MINIMUM VALUES AT THESE PERCENTAGES OF THE MAIN BEAM INTENSITY.
4. THE INTENSITY REQUIREMENTS FOR THE ANGLES BELOW THE SURFACE OF THE PAVEMENT MAY BE DISREGARDED.

4.8.4. Adjustment and Tolerances. The location of the pairs of light bars may be adjusted a maximum of 0.6 meters (2 feet) longitudinally to avoid construction joints. Installation tolerance for the fixtures is 0.27 meters (11 inches) from the design location in any direction. The mounting surface of the fixture must be level within 1 degree in any direction and the horizontal aiming must be within 1 degree.

- 4.8.5. Equipment. Use in-pavement fixtures with no part protruding more than 0.01 meters (0.5 inches) above the surrounding surface. (See paragraph 13.10.7.)
- 4.8.6. Power, Control and Monitoring. The requirements in paragraphs 4.7.6 through 4.7.8 for RCLs apply.
- 4.8.7. Compliance with International Standards:
- 4.8.7.1. ASCC. These standards meet the requirements of AIR STD 90/27, for Category II conditions.
- 4.8.7.2. NATO. These standards meet the requirement of STANAG 3316.
- 4.8.8. See FAA AC 150/5340-4 for more information.

Chapter 5

STANDARDS FOR TAXIWAY LIGHTING

5.1. Taxiway Edge Lighting:

5.1.1. Purpose. Taxiway edge lights define the lateral limits and direction of a taxiing route. Taxiway edge lighting must be installed for night VMC operations and for day and night instrument operations.

5.1.2. Configuration. The configuration consists of a line of lights paralleling each side of the taxiway. Provide taxiway lighting for all regularly-used taxiing routes. Locate the line of taxiway edge lights on each side of the taxiway no more than 3 meters (10 feet) from the edge of the full-strength paving, and no closer than the edge of the full-strength paving. The line of lights on both sides of a taxiway must be the same distance from their respective taxiway sides. When a runway or a portion of a runway is part of a regularly used taxiing route, provide taxiway lights in addition to the runway lights. To determine the spacing of lights along the taxiway length, such as intersections with runways and other taxiways or changes in alignment or width, a discontinuity on one side of a taxiway applies to the other side as well; figure 5.1 illustrates most situations. Place an edge light at each discontinuity. For intersecting pavements, place them at the point of tangency (PT) of each fillet. Place a companion light on the side opposite the discontinuity as well.

5.1.2.1. Straight Sections. Place edge lights along all straight taxiway edges at uniform intervals between the lights, as in paragraph 5.1.2. Where the length of the section is greater than 120 meters (400 feet), the spacing must not exceed 60 meters (200 feet). If the section under consideration is opposite an intersecting taxiway or apron area, the uniform spacing must not exceed 1/2 the width of the intersecting taxiway. Where the length of the section is less than 120 meters (400 feet) the spacing must not exceed 30 meters (100 feet). Where the light spacing exceeds 30 meters (100 feet), place one additional light 12 meters (40 feet) from each end of the section. Where the section is opposite an ending taxiway, the uniform spacing must not exceed 1/2 the width of the ending taxiway. Place companion lights along the opposite edge where there is no intersecting pavement. Place all companion lights on lines perpendicular to the taxiway centerline. (See figure 5.1.)

5.1.2.2. Curved Sections. Place edge lights along all curved taxiway sections. Uniformly space the lights on the outer line at a distance, not to exceed the value obtained from the formula given in figure 5.2. Place the lights on the inner line on radials from the outer line of lights, except where the resultant spacing would be less than 6 meters (20 feet). In this case, select spacing not less than 6 meters (20 feet) for the inner line of lights and place the outer line of lights on radials from the inner line.

5.1.2.2.1. Place uniformly spaced edge lights at all fillets as shown in figure 5.3. The spacing must not exceed one half the width of the straight taxiway section. On all curves exceeding 30 degrees of arc, there must be a minimum of three lights between the PTs.

5.1.2.3. Taxiway End Lights. Where a taxiway ends at a crossing taxiway, place two yellow lights spaced 0.5 meters (1.5 feet) apart and in the line of the edge lights of the crossing taxiway. Center them on the point

Diagram illustrating the bridge deck layout. The left side shows a cross-section with two lanes, each 13.5M (45FT) wide, separated by a 13.5M (45FT) gap. The right side shows a plan view of the bridge deck with a total width of 32M (106FT) and a spacing of 2 SPACES @ 16M (53FT) between the centerlines of the lanes.

Diagram illustrating a 3-space layout with 8M spacing. The layout shows a grid of points (circles) connected by lines. The horizontal spacing is labeled as 8M (294FT) and the vertical spacing is labeled as 3 SPACES @ 29.3M (98FT). The layout is bounded by a line labeled PT on the left and right.

4 SPACES @ 23.1M (77FT)
(ONE BLUE LIGHT ELIMINATED)

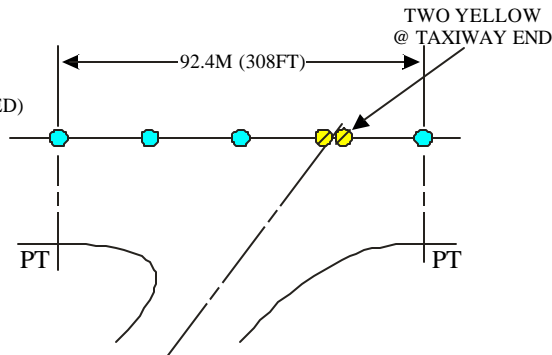
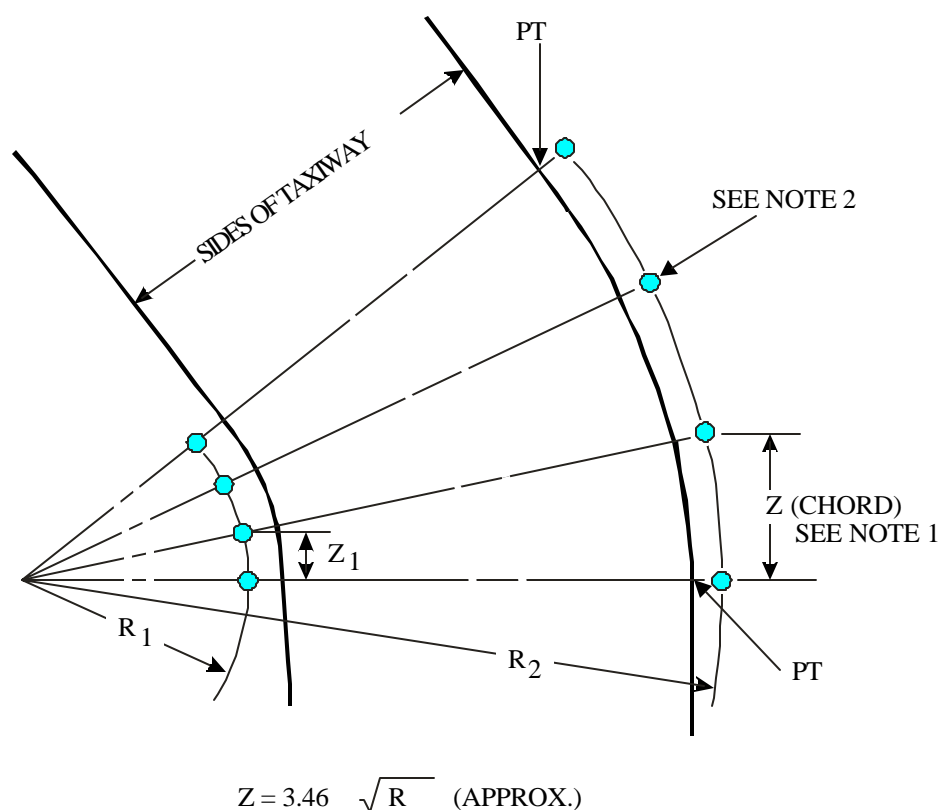


Diagram illustrating the layout of a taxiway boundary (TWB) and taxiway end (TWE) lights. The distance between the TWE and TWB is 100m (328ft). The TWE is marked by two yellow lights. The TWB is marked by six blue lights. The distance is divided into six equal spaces of 16.67m (54.7ft) each. A dashed line indicates the centerline, and a solid line indicates the boundary. A curved line represents the taxiway edge. Labels include 'TWE', 'TWB', 'PT', 'W/2', and '6 SPACES @ 16.67M (54.7FT)'.

The diagram shows a horizontal line representing the apron layout. It is bounded by two vertical lines labeled "PT" (Property Line) at the ends. The total length is indicated as 158M (480FT). This length is divided into three equal spaces, each 48M (160FT) wide, separated by vertical lines. The distance from the first vertical line to the first "PT" is 12M (40FT), and the distance from the last vertical line to the last "PT" is also 12M (40FT). The central area is labeled "APRON".

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Figure 5.2. Taxiway Edge Lighting Configuration (Curves).



NOTES:

1. SPACE LIGHTS UNIFORMLY ON BOTH SIDES OF TAXIWAY BETWEEN POINTS OF TANGENCY (PT). DETERMINE SPACING BY DIVIDING TOTAL ARC INTO INCREMENTS Z. SELECTING NO VALUE FOR Z WOULD CAUSE Z₁ TO BE LESS THAN 6M (20FT) (SEE TEXT).
2. ON ALL CURVES IN EXCESS OF 30 DEGREES OF ARC, USE A MINIMUM OF THREE EDGE LIGHTS, INCLUDING THOSE AT PTs.

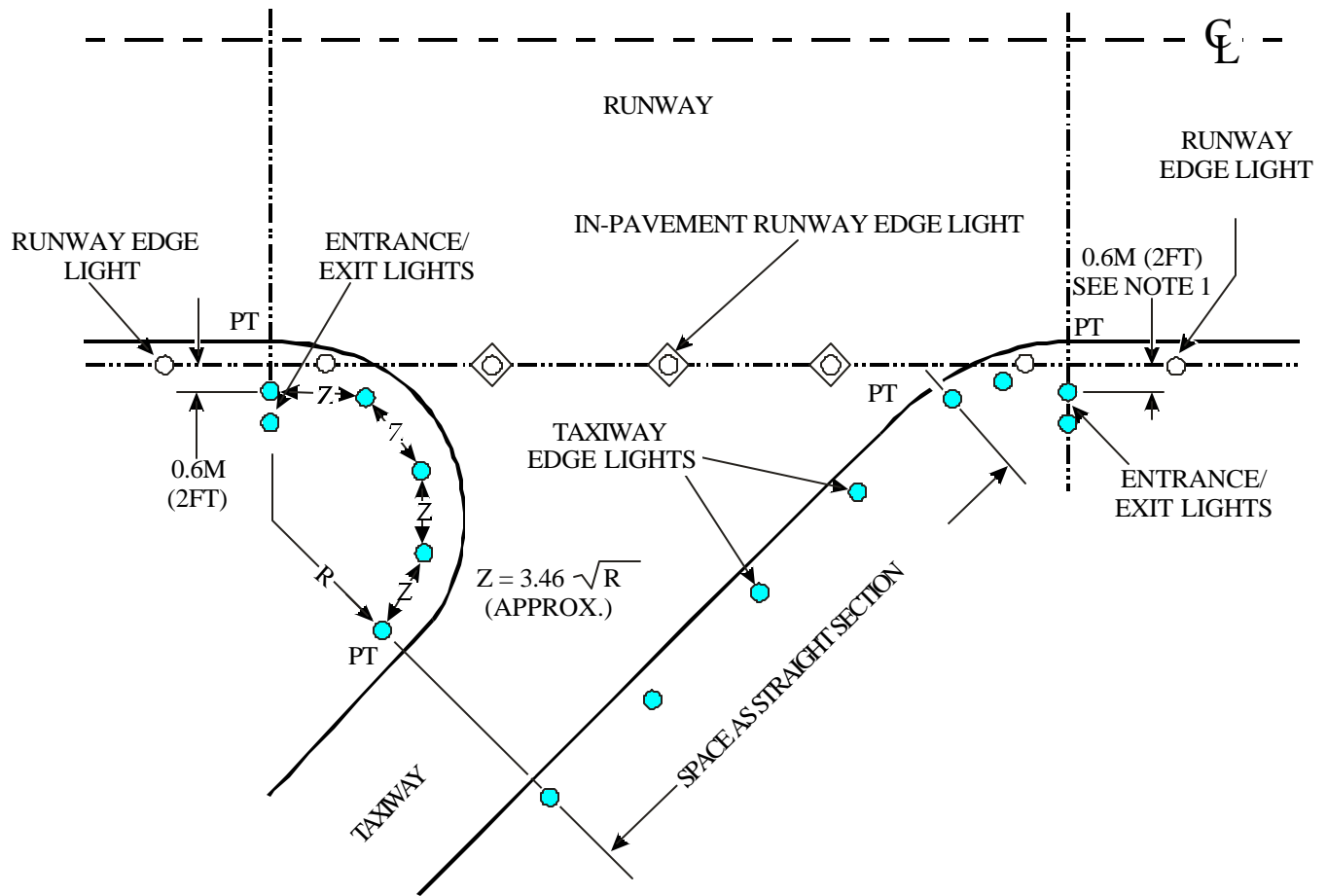
5.1.2.4. Entrance/Exit Lights. On intersections of taxiways with runways or aprons, place entrance/exit lights at the point of tangency of the taxiway fillet with the runway or apron. Do not place them at an intersection of taxiways. An entrance/exit light consists of 2 taxiway edge lights spaced 1.5 meters (5 feet) apart. One is located 1.5 meters (5 feet) out, on a line extending through the first light and perpendicular to the side of the runway or apron. (See figure 5.3.)

5.1.2.5. Apron Taxiways. For a taxiway that is adjacent to, or on the edge of, an apron, the taxiway edge lights are usually placed only on the side of the taxiway furthest from the apron. ("Taxiing" routes through an apron will not have these lights.)

5.1.3. Tolerances. Adjust the longitudinal location of any light a maximum of 1.5 meters (5 feet) to avoid installation problems. Move the companion light the same amount, if practical, to maintain the relationship

between them. Install taxiway edge lights within 0.15 meters (6 inches) laterally or longitudinally of the design location.

Figure 5.3. Taxiway Edge Lighting Configuration Entrance/Exit.



NOTES:

1. TAXIWAY LIGHTS MUST NOT BE IN LINE WITH RUNWAY EDGE LIGHTS.
2. PT = POINT OF TANGENCY

5.1.4. Photometric Requirements. Optimum aiming of lights depends on the design and output of the fixtures used in the system. Taxiway edge lights must be omni-directional and emit aviation blue light with a minimum intensity of 2 candelas from 0 to 6 degrees vertically and a minimum of 0.2 candelas at all other vertical angles.

5.1.5. Equipment. Use frangible mounted elevated fixtures in all areas, including Category II and Category III operations, as noted below. Mount elevated fixtures a maximum of 0.35 meters (14 inches) above grade. Where there are frequent snow accumulations of 0.30 meters (12 inches) or more, the mounting height may be increased to 0.76 meters (30 inches).

5.1.5.1. Size the fixture base which supports the elevated fixture and houses the isolation transformer to accept an in-pavement fixture. This facilitates future runway and taxiway configuration changes or modifications where an elevated fixture may not be suitable.

5.1.5.2. To reduce the “sea of blue lights” effect at an airfield that has many taxi routes, hoods may be used on elevated fixtures. Do not use hoods on entrance or exit light fixtures.

5.1.5.3. Where elevated lights may be damaged by jet blast or operation of an arresting gear, or where they interfere with aircraft operation such as B-52 outrigger gears, use in-pavement fixtures. See paragraph 13.11.1 for applicable fixtures used.

5.1.6. Power Requirements. Provide a main power system and circuits which permit independent control of the taxiways. Provide standby power only for those taxiways supporting precision instrument approaches. Transfer time from the failed power system must not exceed 15 seconds.

5.1.7. Control Requirements. Taxiway lighting circuits must be segmented and controlled to provide the degree of flexibility required for airfield operations. (See figure 5.4.) Provide remote on/off control for all taxiway segments, and provide a three step intensity control.

5.1.8. Monitoring Requirements. There is no requirement for monitoring taxiway circuits.

5.1.9. Compliance with International Standards.

5.1.9.1. ASCC. These standards meet the requirements of AIR STD 90/27, except for the light spacing on curves.

5.1.9.2. NATO. These standards meet the requirements of STANAG 3316 except for the light spacing on curves.

5.2. Taxiway Centerline Lights:

5.2.1. Purpose. Taxiway centerline lights are a system of aviation green in-pavement lights installed along the taxiway centerlines to provide alignment and course guidance information that supplement edge lighting. They may be installed where it is impractical to install taxiway edge lights. However, they are optional at airfields designed for Category II and required at airfields designed for Category III operations, on the taxiways which support these operations. They are also used instead of edge lights on taxiway sections that cross aprons, ramps, or other large paved areas.

5.2.2. Configuration. Install taxiway centerline lights in smooth lines along the taxiway centerline. To avoid construction joints or markings, the line of lights may be offset uniformly a maximum of 0.6 meters (2 feet) from the centerline. Determine the light spacing as follows:

5.2.2.1. Place a light at each holding position, at each PT of a curved section, at each taxiway end, at each intersection with a runway edge or apron, and at the PTs of all fillets. Where taxiways cross, place a light at the intersection of the centerlines.

5.2.2.2. Place uniformly spaced lights between the points defined above, along all straight and curved sections of the taxiway. The uniform spacing will approach, but not exceed, the criteria given in figure 5.5. The location of individual lights may be adjusted along the line of lights a maximum of 0.6 meters (2 feet) to avoid construction problems.

5.2.2.3. At taxiway intersections, place lights along an arc drawn tangent to the centerlines of the taxiways (or lines of lights) in the direction of all aircraft turns. In order to reduce confusion where aircraft turns are not anticipated, the arc of lights may be omitted. The minimum clearance to the inner edge of either taxiway must be equal to one half the width of the narrower taxiway. Select the largest radius that will provide the clearance for the arc of lights. Do not install taxiway centerline lights on runway surfaces, except as specified for runway exit lights.

5.2.3. Tolerances. Taxiway centerline lights must not be more than 0.07 meters (3 inches) off of the designated line of lights and not more than 0.15 meters (6 inches) from the designated locations along the line of lights.

5.2.4. Equipment. (See paragraph 13.11.2.) Use in-pavement fixtures which do not protrude more than 0.01 meters (0.50 inch) above the pavement. They must be bi-directional aviation green except as follows:

5.2.4.1. At crossing taxiways, the light at the intersection must be omni-directional aviation yellow.

Figure 5.4. Taxiway Circuit Layout.

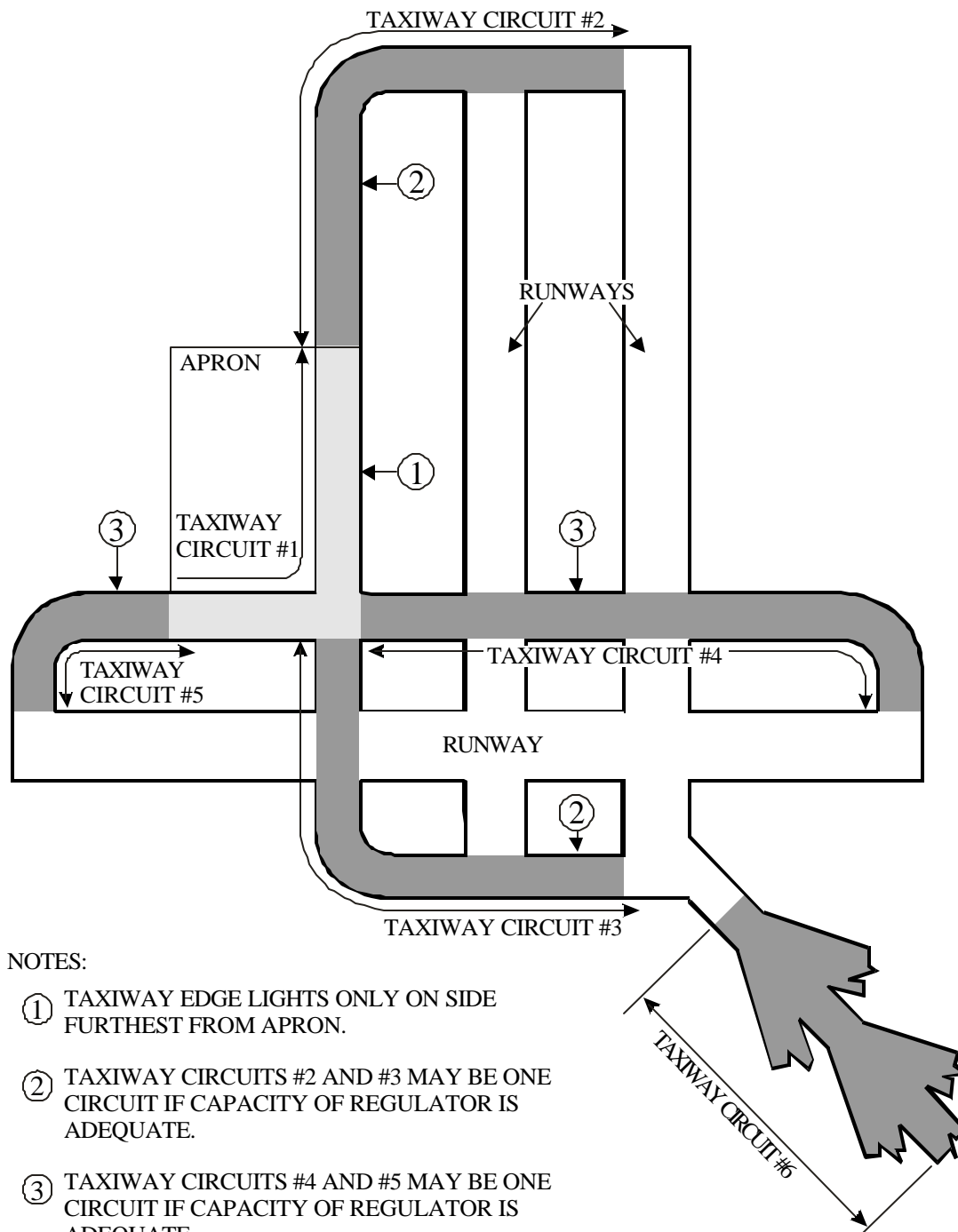
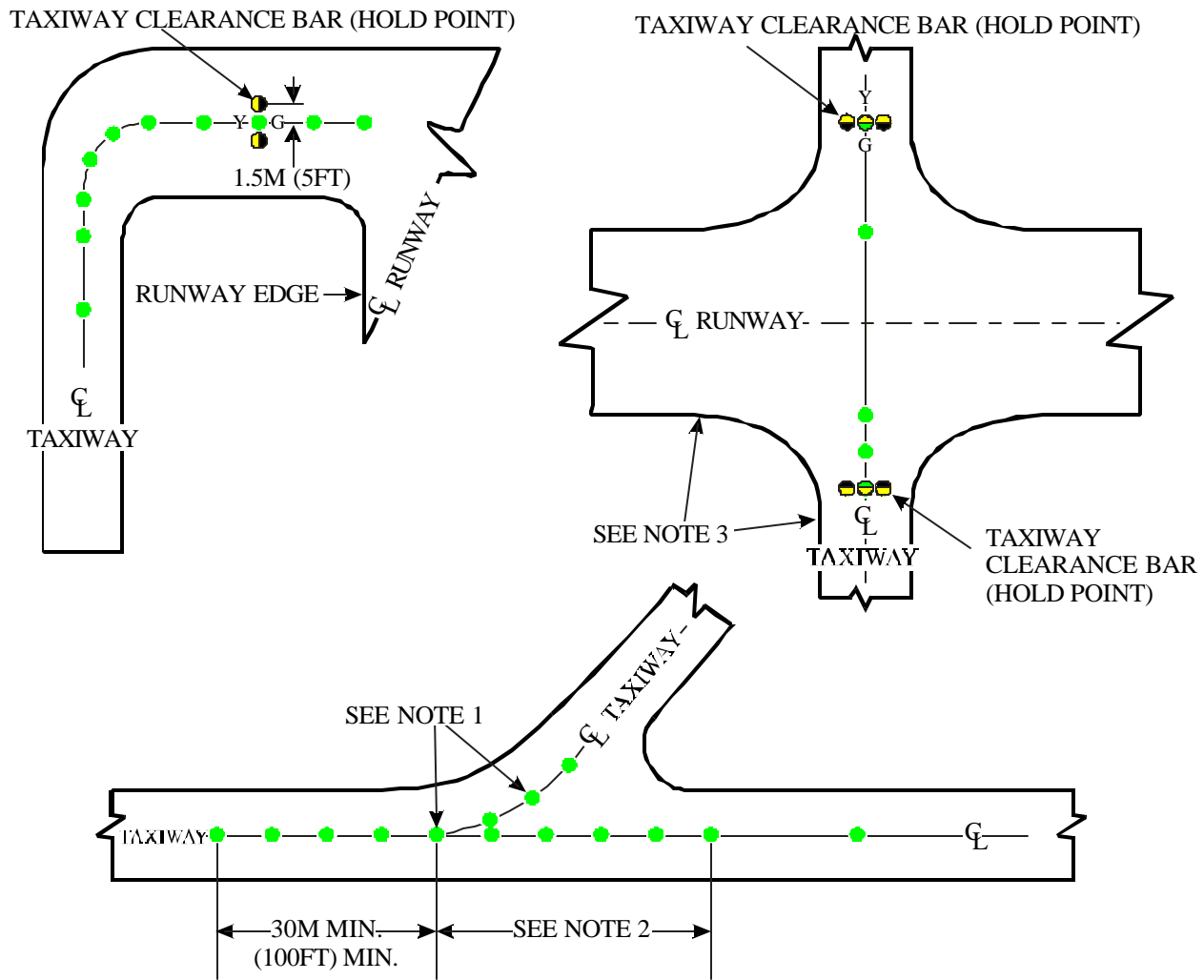


Figure 5.5. Taxiway Centerline Lighting Configuration.



LONGITUDINAL SPACING CRITERIA

	CAT. II IFR	ALL OTHER
NOMINAL	15M (50FT)	30M (100FT)
AT INTERSECTIONS (SEE NOTE 2)	15M (50FT)	15M (50FT)
CURVES RADIUS LESS THAN 120M (400FT)	3.75M (12.5FT)	7.5M (25FT)
(SEE NOTE 1) RADIUS 122M (400FT) TO 360M (1200FT)	7.5M (25FT)	15M (50FT)
RADIUS GREATER THAN 360M (1200FT)	15M (50FT)	30M (100FT)

NOTES:

1. LOCATE LIGHTS AT PT1 AND PT2, AND SPACE INTERMEDIATE LIGHTS EQUALLY ALONG SELECTED CURVE IN COMPLIANCE WITH SPACING CRITERIA.
2. SPACE LIGHTS EQUALLY BETWEEN PT1 AND CLEARANCE BAR (HOLD POINT) LIGHTS.
3. RUNWAY AND TAXIWAY EDGE LIGHTS NOT SHOWN.

LEGEND:

- $\frac{Y}{G}$ BIDIRECTIONAL, GREEN AND YELLOW
 BIDIRECTIONAL, GREEN
 UNIDIRECTIONAL, YELLOW

5.2.4.2. On taxiways where the aircraft movement is in one direction only, the lights may be uni-directional and facing the oncoming aircraft.

5.2.4.3. Where hold lights are installed, the centerline light must be aviation yellow facing the holding aircraft.

5.2.5. Photometric Requirements. Taxiway centerline lights must be bi-directional and emit aviation green light at three intensity steps: 100 percent, 30 percent, or 10 percent of full brightness. The minimum intensities and beam widths are shown in table 5.1.

Table 5.1. Taxiway Centerline Light Intensity and Beam Widths.

APPLICATION	AVERAGE INTENSITY OF MAIN BEAM	----- BEAM WIDTH -----			
		50% OF MAIN BEAM AVERAGE		10% OF MAIN BEAM AVERAGE	
		HOR.	VERT.	HOR.	VERT.
Category II					
Straight	20 cd	± 10	1 to 4	± 16	0.5 to 10
Curved	20 cd	± 30	1 to 4	± 30	0.5 to 10
Category III					
Straight	200 cd	± 3.5	1 to 8	± 4.5	0 to 13
Curved	100 cd	± 30	1 to 10	± 30	0 to 15

5.2.5.1. Horizontal Aiming. Aim lights on straight sections parallel with the taxiway centerline. Aim lights on curved sections along the tangent at the light location.

5.2.6. Power Requirements. Provide a main power system and circuits which permit independent control of the taxiways. Provide standby power only for those taxiways essential for precision instrument approaches. Transfer time from the failed system to standby system must not exceed 15 seconds.

5.2.7. Control Requirements. Provide remote on and off and three step intensity control. The system may be segmented to provide flexibility in choosing taxiway routing.

5.2.8. Monitoring Requirements. There is no monitoring requirement for taxiways.

5.2.9. Compliance with International Standards:

5.2.9.1. ASCC. These standards meet the requirements of AIR STD 90/27.

5.2.9.2. NATO. These standards meet the requirements of STANAG 3316 except for the light spacing on curves.

5.3. Runway Exit Lights:

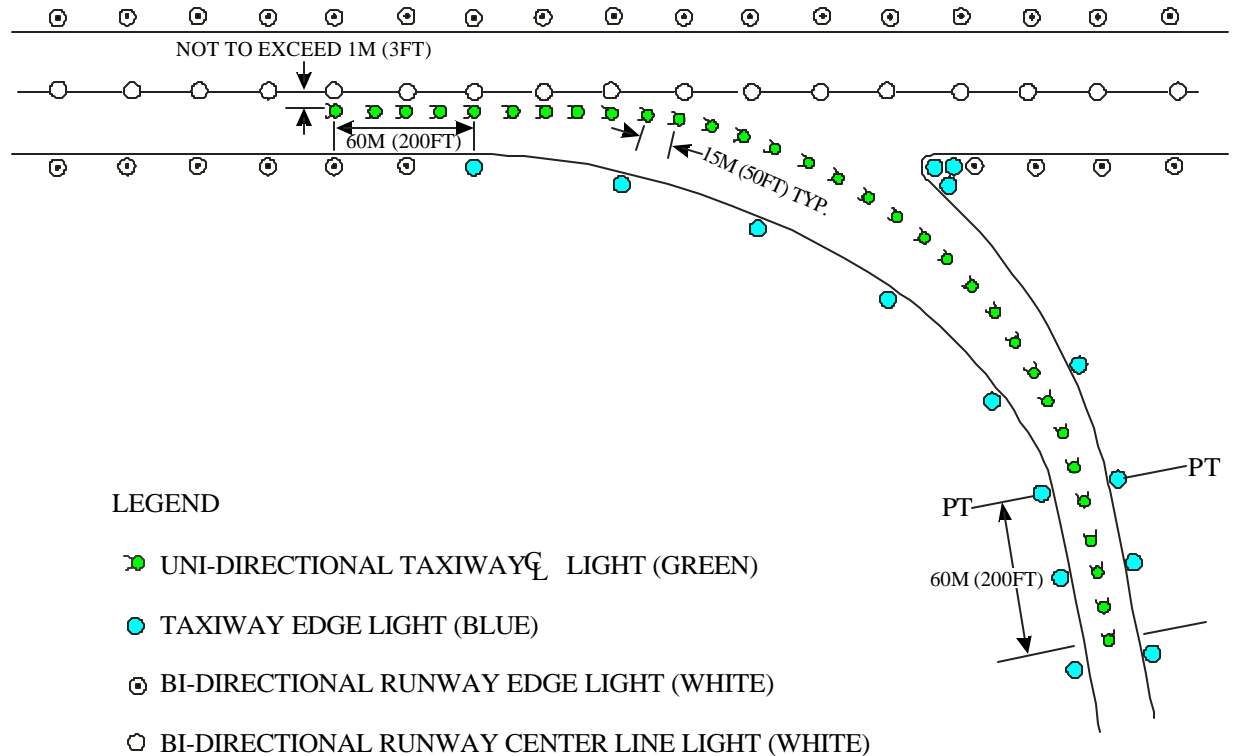
5.3.1. Purpose. Runway exit lights may be added to long radius (high-speed) taxiway exits, or to short radius (low speed) taxiway exits where there is a need to expedite movement of aircraft off the runway. Runway exit lights may be installed with either taxiway edge or taxiway centerline lights.

5.3.2. Configuration:

5.3.2.1. Long Radius Exits. Long radius exit lights are installed on exits with radii exceeding 360 meters (1,200 feet). They consist of a line of uni-directional green taxiway centerline lights. The line begins at a point which is a maximum of 1 meter (3 feet) off the runway centerline and 60 meters (200 feet) before the beginning of the taxiway centerline curve. The line of lights runs parallel to the runway to the beginning of the

taxiway centerline curve. It then follows the taxiway centerline curve to a point which is a minimum of 60 meters (200 feet) beyond the beginning of the straight portion of the taxiway. The lights are uniformly spaced at a distance of not more than 15 meters (50 feet). (See figure 5.6.)

Figure 5.6. Taxiway Long Radius High Speed Exit Lights.



5.3.2.2. Short Radius Exits. Short radius exit lights consist of a line of green taxiway centerline lights. The line of lights begins at a point that is not more than 1 meter (3 feet) off the runway centerline on the near side and is the PT of the exit curve. The radius of the curve should be the largest that will provide a minimum clearance to the pavement edge equal to one half the width of the taxiway. The line of lights runs along the arc to the PT with the taxiway centerline. It then follows the taxiway centerline for a minimum of 60 meters (200 feet). The spacing between the lights is not greater than 7.5 meters (25 feet). (See figure 5.7.)

5.3.3. Adjustments and Tolerances. The requirements in paragraph 5.2.3 for taxiway centerline lights apply.

5.3.4. Photometric Requirements and Horizontal Aiming. The requirements in paragraphs 5.2.5 for taxiway centerline lights apply.

5.3.5. Equipment. Use uni-directional, in-pavement fixtures with no part extending more than 0.01 meters (0.5 inch) above the surrounding pavement. (See paragraph 13.11.2.)

5.3.6. Power Requirement. Provide a main power supply and circuits that permit independent control except on a taxiway with centerline lighting. In this case, they may be connected to and controlled with the taxiway centerline lights.

5.3.7. Control Requirement. Provide remote on/off and intensity control. Runway exit lights may be controlled with associated taxiway centerline lights.

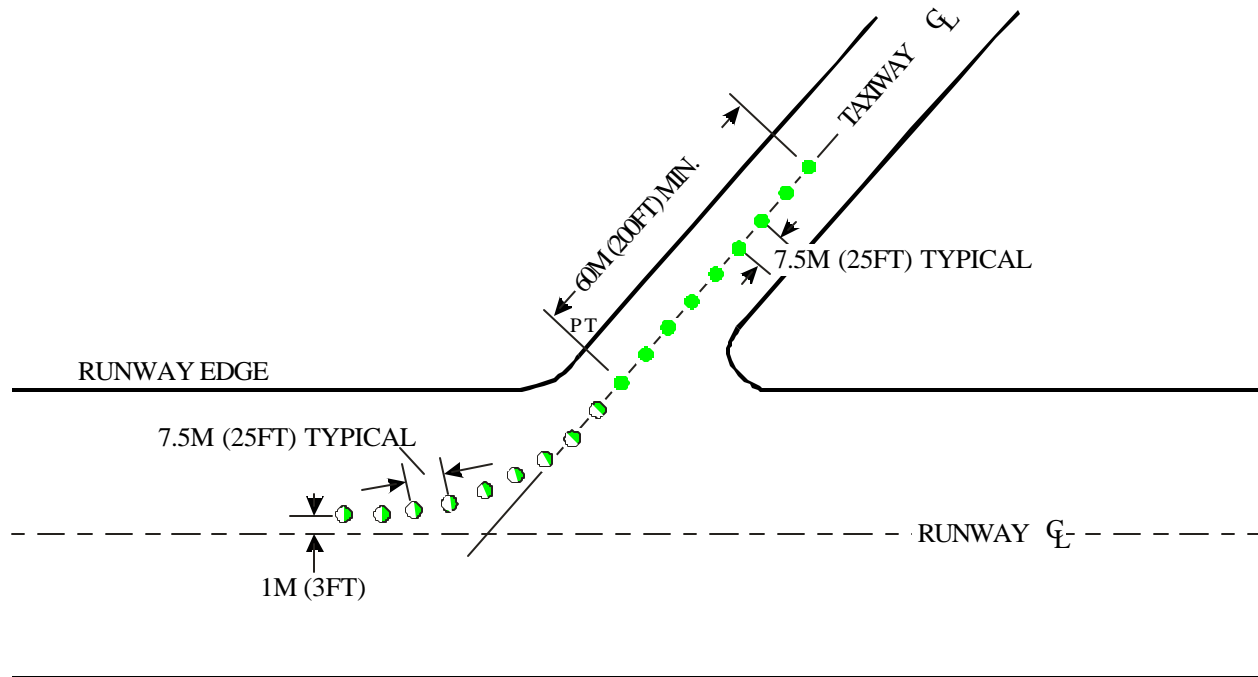
5.3.8. Monitoring Requirements. There are no monitoring requirements.

5.3.9. Compliance with International Military Standards:

5.3.9.1. ASCC. These standards meet AIR STD 90/27.

5.3.9.2. NATO. These standards meet NATO STANAG 3316.

Figure 5.7. Taxiway Short Radius High Speed Exit Lights.



LEGEND

- UNI-DIRECTIONAL LIGHTS (STANDARD TAXIWAY CENTERLINE)
- MAY BE BI-DIRECTIONAL IF USED FOR BI-DIRECTIONAL TRAFFIC

5.4. Taxiway Clearance Bars:

5.4.1. Purpose. Clearance bars serve two purposes:

5.4.1.1. In low visibility, clearance bars warn pilots and vehicle drivers that they are approaching a hold point (other than a runway holding position). They are installed at designated hold points on the taxiway for operations below 600 feet (183 meters) RVR.

5.4.1.2. At night and in inclement weather, clearance bars warn pilots and vehicle drivers that they are approaching an intersecting taxiway. They are generally installed at taxiway intersections where the taxiway centerline lights do not follow the taxiway curve and taxiway edge lights are not installed.

5.4.2. Configuration. A clearance bar consists of a row of three in-pavement yellow lights to indicate a low visibility hold point. The fixtures are normally uni-directional but may be bi-directional depending upon whether the hold point is intended to be used in one or two directions. In addition, with the below exceptions, clearance bars are installed (without regard to visibility) at a taxiway intersection with non-standard fillets or where the taxiway centerline lights do not follow curves at intersections. Clearance bars installed for this purpose consist of uni-directional fixtures.

- 5.4.2.1. Clearance bars may be omitted if taxiway edge lights are installed at the intersection.
- 5.4.2.2. If the angle between the centerlines of any two adjacent segments of the pavement is 90 degrees \pm 10 degrees, clearance bars at a “T” or “+” shaped taxiway/taxiway intersection may be substituted by or supplemented with an omni-directional yellow taxiway intersection light (L-852E or F, as appropriate) installed near the intersection of the centerline markings.
- 5.4.2.3. The clearance bar located on an exit taxiway may be omitted if it would be located before, or within 200 feet (61 meters) beyond, a runway holding position (as viewed while exiting the runway).
- 5.4.3. Location of a Clearance Bar Installed at a Low Visibility Hold Point. A low visibility hold point consists of a taxiway/taxiway holding position marking, a geographic position marking, and a clearance bar. However, hold points are not necessarily located at taxiway/taxiway intersections. In-pavement clearance bar lights are centered on an imaginary line that is parallel to, and 610 millimeters (2 feet) from, the holding side of the taxiway/taxiway holding position marking. The lights may vary from this imaginary line up to \pm 50 millimeters (\pm 2 inches) (perpendicular to the holding position marking). If a conflict occurs with rigid pavement joints or other undesirable spots, the taxiway/taxiway holding position marking, geographic position marking, and the clearance bar may all be moved longitudinally any amount necessary to resolve the conflict. However, if the hold point is located at a taxiway/taxiway intersection, the aforementioned items should all be moved away from the intersecting taxiway the minimum necessary to resolve the conflict. If a conflict occurs between the center fixture in the clearance bar and a centerline light, the center fixture may take the place of an existing centerline light, and a new centerline light should be installed.
- 5.4.4. Location of a Clearance Bar Installed at a Taxiway Intersection. A clearance bar installed at a taxiway intersection is located in accordance with the criteria in of paragraph 5.4.3 if that location is established as a hold point and taxiway/taxiway holding position markings are present. Otherwise, the clearance bar should be located in the same manner as if the holding position marking were present. This allows room for the possible future installation of the marking.
- 5.4.4.1. Lateral Spacing. The center light of the clearance bar is installed in-line with existing or planned taxiway centerline lights. The two remaining lights are installed outboard of the center fixture on 1.5 meter (5 foot) intervals, center-to-center. The outboard fixtures may be moved laterally a maximum of \pm 305 millimeters (\pm 1 foot) in order to avoid undesirable spot, i.e. conduit.
- 5.4.5. Light Beam Orientation for Clearance Bars. The axis of the light beam for each fixture should be parallel to the centerline of the designated taxiway path with a tolerance of \pm 1 degree.
- 5.4.6. Equipment. Use in-pavement fixtures with no part extending more than 0.01 meters (0.50 inches) above the surrounding pavement. Hold lights must emit uni-directional aviation yellow light toward the holding aircraft. When installed with taxiway centerline lights, the center light must be bi-directional aviation yellow/green with the yellow light toward the holding aircraft.
- 5.4.7. Photometric Requirements. Hold lights must emit aviation yellow light. All other photometric requirements in paragraph 5.2.5 for straight section taxiway centerline lights apply.
- 5.4.8. Fixtures. Power and Control Requirements. The requirements for taxiway centerline lights apply. Power and control the fixtures with the associated taxiway lighting system.
- 5.4.9. Monitoring. There is no requirement for monitoring.
- 5.4.10. Compliance with International Military Standard. ASCC and NATO Standards contain no comparable systems.

5.5. Runway Guard Lights (RGLs):

- 5.5.1. Purpose. RGLs provide a distinctive warning to anyone approaching the runway holding position that they are about to enter an active runway.

5.5.2. Configuration. Elevated and in-pavement RGLs serve the same purpose and are not generally both installed at the same runway holding position. However, if snow could obscure in-pavement RGLs or there is an acute angle between the holding position and the direction of approach to the holding position, it may be advantageous to supplement in-pavement RGLs with elevated RGLs. Each elevated RGL fixture consists of two alternately illuminated uni-directional yellow lights. In-pavement RGLs consist of a row or alternately illuminated uni-directional yellow lights.

5.5.3. Location of In-pavement Runway Guard Lights. In-pavement RGLs are centered on an imaginary line that is parallel to, and 610 millimeters (2 feet) from, the holding side of the runway holding position marking. The lights may vary from this imaginary line up to ± 50 millimeters (± 2 inches) in a direction perpendicular to the holding position marking. If a conflict with rigid pavement joints occurs, the RGLs may be moved away from the runway the minimum distance required to resolve the conflict.

5.5.3.1. Lateral Spacing – Preferred Method. The lights are spaced across the entire taxiway, including fillets and holding bays, on intervals of 3 meters (9 feet, 10 inches), ± 50 millimeters (± 2 inches), center-to-center. The lights are spaced in relation to a reference fixture that is installed in-line (longitudinally) with existing or planned taxiway centerline lights. However, it is not intended that the reference fixture replace a taxiway centerline light. If a conflict between the reference fixture and a centerline light occurs, the reference fixture may take the place of an existing centerline light and a new centerline light should be installed in accordance with the criteria in Paragraph 3c of FAA AC 150/5340-28. If the holding position marking is intersected by multiple taxiway centerline markings, the reference fixture should be set at the centerline. A fixture whose outboard edge falls at a point less than 610 millimeters (2 feet) from the defined edge of the taxiway (outboard edge of the taxiway marking) may be omitted. Individual fixtures may be moved laterally maximum of ± 305 millimeters (± 1 foot) in order to avoid undesirable spots, i.e. conduit. NOTE: Generally, undesirable spots must be avoided by a total of 610 millimeters (2 feet). If this cannot be met by applying the aforementioned ± 305 millimeter (± 1 foot) tolerance, then the following alternate method should be used.

5.5.3.2. Lateral Spacing – Alternate Method. The following alternate method of spacing the lights should be followed if it is not possible to meet the preferred method specified in paragraph 4b(1) of FAA AC 150/5340-28. The lights are spaced across the entire taxiway, including fillets and holding bays. If it is possible to meet paragraph 4b(1) requirements by allowing the reference fixture to be moved any amount laterally, then that method should be used. Otherwise, the lights should be spaced as uniformly as possible with a minimum spacing of 2.4 meters (8 feet) and a maximum of 4 meters (13 feet).

5.5.3.3. Light Beam Orientation for In-pavement RGLs. The L-868 bases for in-pavement RGLs should be installed such that a line through one pair of boltholes on opposite sides of the base is parallel to the runway holding position marking. Each fixture is installed so that the light beam faces away from the runway and is perpendicular to the runway holding position marking within a tolerance of ± 1 degree. For some pavement configurations, it may be necessary to orient the lights at some angle to the marking. To accomplish this, install a 12 bolt-holebase using the above procedure. This allows the light fixtures to be adjusted 30 degrees left or right, as required.

5.5.4. Location of Elevated RGLs. Elevated RGLs are collocated with the runway holding position marking and are normally installed on each side of the taxiway. Generally, elevated RGLs should be located as close as practical to the taxiway edge to maximize their conspicuity. The distance from the defined taxiway edge to the near side of an installed light fixture should be 3 to 5 meters (10 to 17 feet). In order to avoid undesirable spots, the RGL may be moved up to 3 meters (10 feet) farther from the runway, but may not be moved toward the runway. If a stop bar is installed at the runway holding position, the elevated RGL should be located at least 1 meter (3 feet, 6 inches) outboard of the elevated stop bar light. The RGL should not be located where it will interfere with the readability of the runway holding position sign.

5.5.4.1. Light Beam Orientation for Elevated RGLs. RGLs should be oriented to maximize the visibility of the light by pilots of aircraft approaching the runway holding position. In general, the orientation should be specified by the design engineer to aim the center of the light beam toward the aircraft cockpit, when the aircraft is between 45 meters (150 feet) and 60 meters (200 feet) from the holding position, along the predominant taxi path to the holding position. The vertical aiming angle should be set between 5 degrees and 10 degrees above the horizontal. The designer should specify aiming of the lights such that the steady burning intensity at all viewing positions between 45 meters (150 feet) and 60 meters (200 feet) from the holding position is at least 300 cd when operated at the highest intensity step. (Refer to FAA AC 150/5345-46 for specifications for the light intensity and beamspread of the L-804 RGL fixture.) If these criteria cannot be met for all taxi paths to the holding position, consider the following: use of multiple fixtures aimed to adequately cover the different taxi paths, use of in-pavement fixtures to increase the viewing coverage, or aiming the single fixtures on each side of the holding position to optimize the illumination of the predominant taxi path.

5.5.5. Equipment. Install the hold position edge lights (Wig-Wag) fixtures on light bases, or on conduit set in concrete foundations, using frangible supports. The transformers, or power supply unit may be placed in the same light fixture base. The light emitted must be aviation yellow, and alternately flash 50 to 60 times per minute. The illumination period of each flash must not be less than 1/2 or more than 2/3 of the total cycle. See figure 13.25 for a typical fixture.

5.5.6. Power, Control and Monitoring. Provide the electrical power for the Wig-Wag lights with the associated taxiway edge or centerline lights. The intensity control may be from the taxiway light circuit, or by photoelectric switch. The lowest intensity must not be less than 30 percent of the rated intensity. There is no monitoring requirement.

5.5.7. Compliance With International Standards. The ASCC and NATO standards do not contain comparable systems.

Chapter 6

STANDARDS FOR OBSTRUCTION LIGHTING

6.1. Purpose. Obstruction lighting defines the vertical and horizontal limits of natural or manmade objects which are considered a hazard to air navigation. Typical examples of various obstruction lighting arrangements are shown in figures 6.1 through 6.4.

6.2. Objects to be Lighted. Objects that penetrate the planes and surfaces defined in UFC 3-260-01 are hazards to air navigation and must have obstruction lights installed. Other objects, which are hazards due to their nature or location even though they do not penetrate the planes and surfaces, as defined above, must also be lighted. This includes obstructions that affect TERPS criteria. Construction or objects which may impact navigable airspace under the provisions of FAR Part 77 are also subject to the administrative procedures in FAA AC 70/7460-1, *Obstruction Marking and Lighting*, for determining obstruction marking and lighting requirements. Also, obstruction lighting is required on the facilities and other obstructions along the periphery of the Building Restriction Line defined in UFC 3-260-01.

6.3. Lighting Configuration. The number and arrangement of obstruction lights must ensure unobstructed visibility of one or more lights from an aircraft at any normal angle of approach. Arrange obstruction lights as specified in FAA AC 70/7460-1.

Figure 6.1. Obstruction Light Configuration, Height up to 105 Meters (350 Feet).

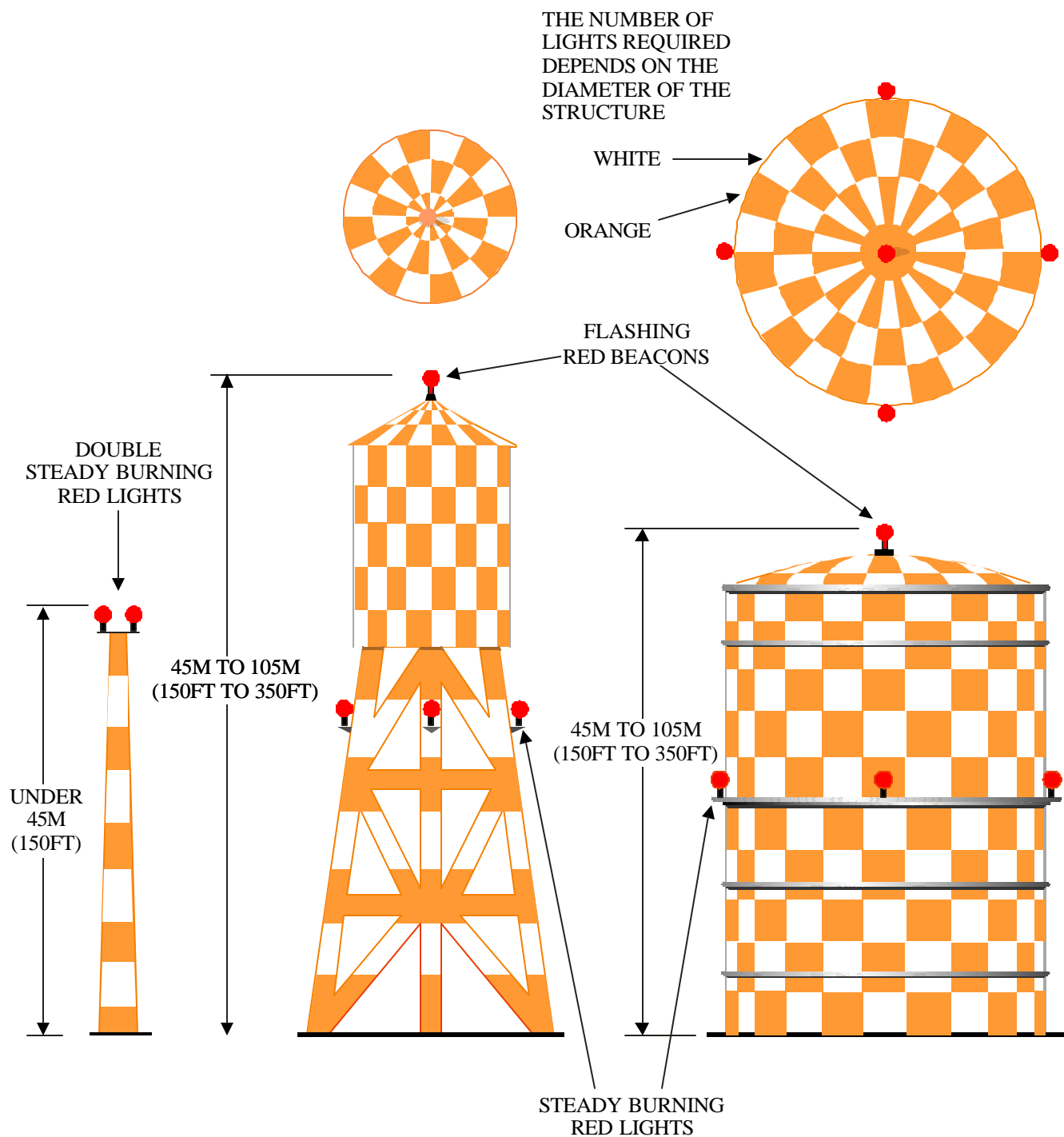


Figure 6.2. Obstruction Light Configuration, Height 45 to 105 Meters (150 to 350 Feet).

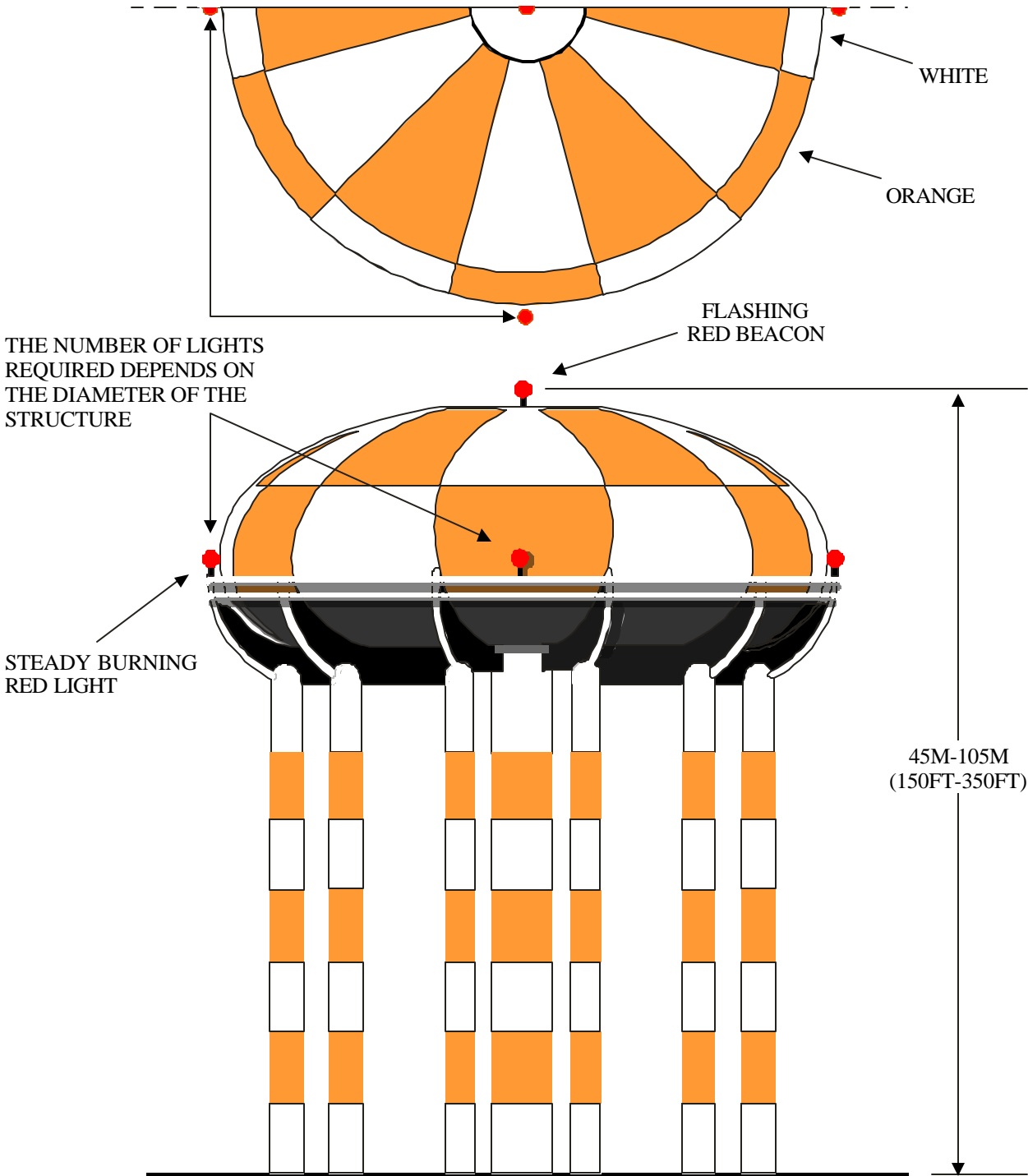


Figure 6.3. Obstruction Light Configuration, Height 107 to 213 Meters (350 to 700 Feet).

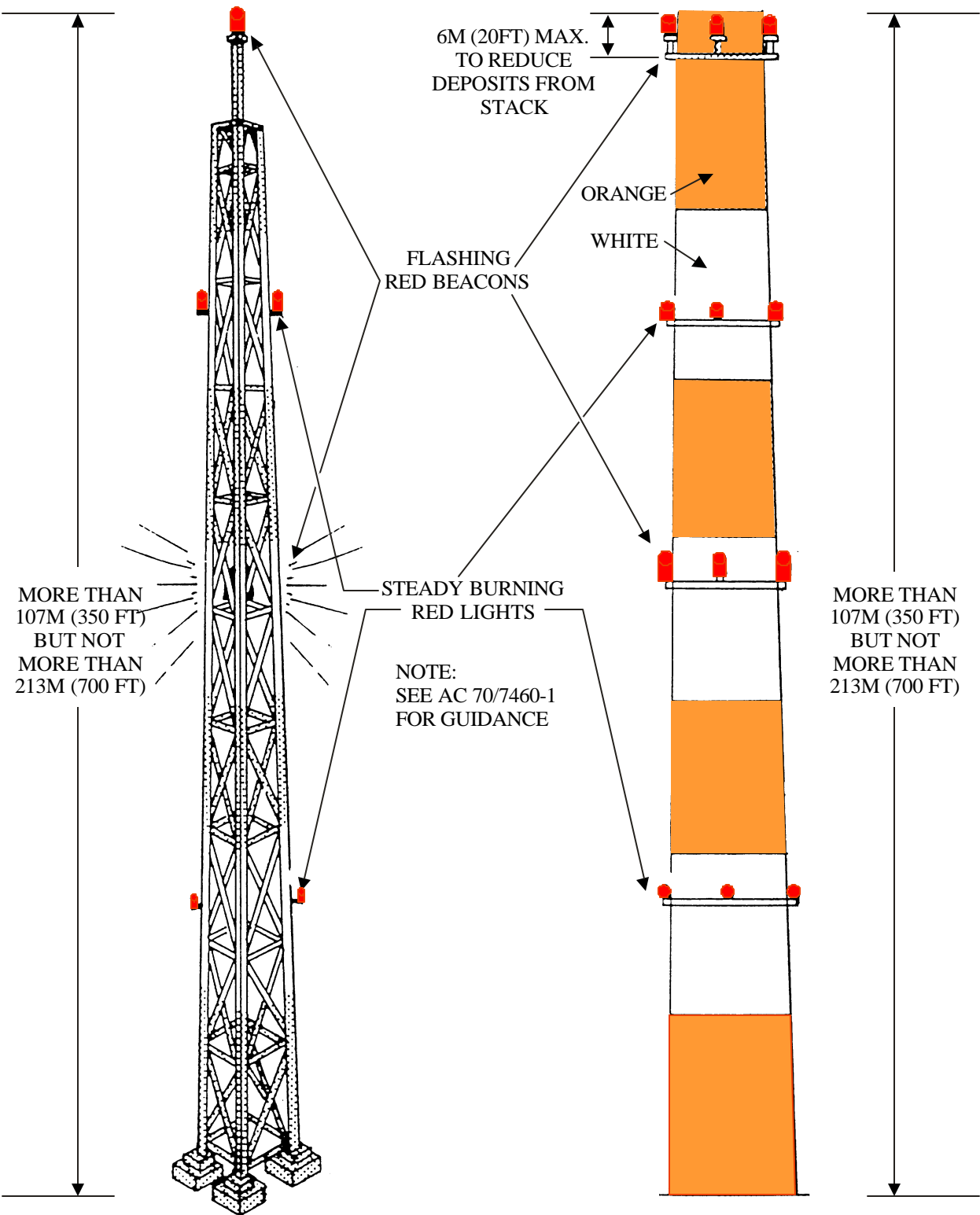
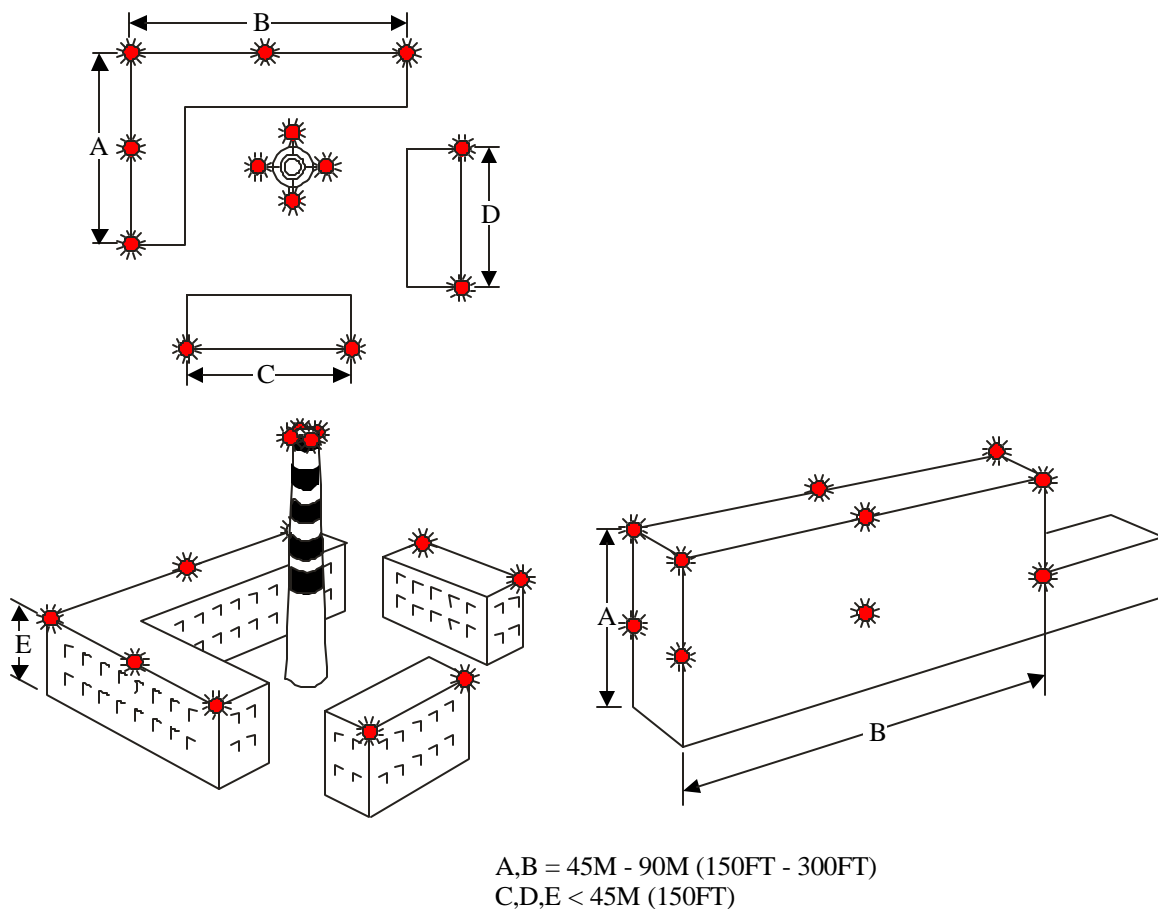


Figure 6.4. Obstruction Lights on Buildings.



6.4. Lighting Versus Day Marking. Flashing white obstruction lighting may be used instead of obstruction marking on structures less than 60 meters (200 feet) tall with Major Command approval. Do not install these lights in clear zones or on objects in the immediate vicinity of runways where approaching pilots may mistake them for other flashing white lights.

6.5. Waivers. The decision to waive obstruction lighting requirements must be coordinated with appropriate civil aviation authorities to ensure there is no negative impact to civil aviation. (See paragraph 1.8 for Air Force waivers and paragraph 1.9 for US Army waivers.)

6.6. Equipment. For various obstruction light fixtures see paragraph 13.13. The equipment shown meets the requirements of the FAA.

6.7. Power Requirements. Depending on the equipment installed, the power may be from a series circuit or 120 volt multiple circuit. For flashing lights the power is usually 120 volts. Emergency power is not a requirement but is desirable if readily available.

6.7.1. Intensity Requirements. See table 6.1 for required intensity levels.

Table 6.1. Required Effective Intensities of Obstructions Lights.

Intensity step	Minimum Beamspread Vertical (degrees)	Minimum Horizontal (degrees)	Intensity Peak (candelas)
<u>Steady-burning red lights</u>			
Full	10	360	30-150
<u>Flashing red beacon, medium intensity</u>			
Full	3	360	2,000 ± 25%
<u>Flashing red beacon, rotating</u>			
Full	10	360	20,000 min.
<u>Flashing white beacons, medium intensity</u>			
Day/Twilight	3	360	20,000 ± 25%
Night	3	360	2,000 ± 25%
<u>High-intensity flashing white lights, towers and stacks ^{1/}</u>			
Day	3 to 7	360	270,000 ± 25%
Twilight	3 to 7	360	20,000 ± 25%
Night	3 to 7	360	2,000 ± 25%
<u>High-intensity flashing white lights, transmission line supports ^{1/}</u>			
Day	3 to 7	180 or 360	140,000 ± 25%
Twilight	3 to 7	180 or 360	20,000 ± 25%
Night	3 to 7	180 or 360	2,000 ± 25%
<u>Vehicle obstruction beacons</u>			
Full	10	360	40 min. 400 max ^{2/} .
^{1/} Multiple lights may be used to obtain horizontal coverage			
^{2/} The minimum and maximum are for the horizontal plane, but the peak may be greater at higher vertical angles.			

6.8. Control Requirements:

6.8.1. Obstruction lights intended for day marking must remain on at all times and have automatically selected reduced intensity levels for night operations. Other obstruction's lights must be on when the northern sky illumination falls on a vertical surface to a level of not less than 350 lux (35 footcandles), or during daytime, when visibility is restricted. The lights may be turned off when the northern sky illuminance rises to a level of (580 lux) 58 footcandles or more.

6.8.1.1. Dual Lighting. This system consists of red lights for nighttime, and high or medium intensity flashing white lights for daytime and twilight. When the dual system incorporates medium flashing intensity lights on structures 150 meters (500 feet) or less, or high intensity flashing white lights on structures of any height, other methods of marking may be omitted.

6.8.2. If practicable, obstruction lights should be controlled from the airfield lighting control panel. Otherwise use automatic controls and provide a locked auxiliary manual control at ground level on the exterior of the object to be lighted.

6.9. Monitoring Requirements. Obstruction lights should be visually observed for proper operation at least once each 24 hours. If the lighting can not be readily observed, provide a remote monitoring system to indicate the malfunction of all the top lights and any flashing or rotating beacons regardless of their position.

6.10. Compliance with International Standards:

6.10.1. NATO. These standards meet the requirements of STANAG 3346, *Marking and Lighting of Airfield Obstructions*, except for the use of high intensity white lights.

6.10.2. ASCC. These standards meet the requirements of AIR STD 90/19, *Lighting and Marking of Airfield Obstructions*.

Chapter 7

STANDARDS FOR LIGHTING HELIPADS

7.1. General Description. Helipad lighting defines the helicopter landing pad during operations at night and during periods of poor visibility. It is used for single helicopter landing pads when authorized as an operational requirement. For heliport and helicopter landing lanes lighting system criteria, refer to Chapter 8. All lighted helipads must have perimeter lighting; however, local conditions and usage may require the addition of:

7.1.1. Landing direction lights, where there is a preferred landing direction. (See paragraph 7.2.2.)

7.1.2. Approach direction lights, where approach guidance is needed to restrict the path of approach to the helipad. (See paragraph 7.3.2.)

7.1.3. Helipad Instrument Meteorological Conditions (IMC) approach lights, where additional approach guidance is required in IMC.

7.1.4. Pad floodlighting, to assist in ground operations. Helipad floodlights may be used to supplement the helipad perimeter lights when additional lighting is considered necessary to assist with ground operations.

7.1.5. A heliport beacon, where a helipad is not part of an airfield and there is an operational requirement to provide assistance in locating the helipad.

7.2. Helipad Perimeter Lights:

7.2.1. Purpose. Perimeter lights provide visual cues to pilots for identifying the safe operational limits of the helipad during takeoff, landing or hover operations.

7.2.2. Standard Perimeter Light Configuration. Place aviation yellow, omni-directional lights at each corner of the helipad, with three more lights spaced equally along each side between the corner lights. Lights on opposite sides of the helipad must be opposite each other. They must be equidistant and parallel to the extended centerlines of the helipad. They are usually located on the perimeter of the helipad, but may be placed not more than 2.25 meters (7.5 feet) away from the edge of the pad. In-pavement fixtures must be used where taxiing of wheeled helicopters, skid mounted helicopters or other vehicular traffic is required. Elevated light fixtures should preferably be 0.35 meters (14 inches) maximum. Elevated light fixtures may be used where only approach and departure procedures are conducted. (See figure 7.1.)

7.2.3. Hospital Pad Perimeter Light Configuration. The lighting of a hospital helipad is the same as the standard helipad perimeter lights in paragraph 7.2.2, except there are additional wing lights located on the geometric centerlines of the helipad at a distance of 7.5 meters (25 feet), as shown in figure 7.2, outboard of the existing perimeter light fittings.

7.3. Helipad VFR Landing Direction and Approach Lights. These lights are installed whenever it has been determined that the need to indicate a specific landing direction, in the procedure for touchdown or hover at the helipad, is a requirement.

Figure 7.1. Helipad Perimeter Lights, Standard Configuration.

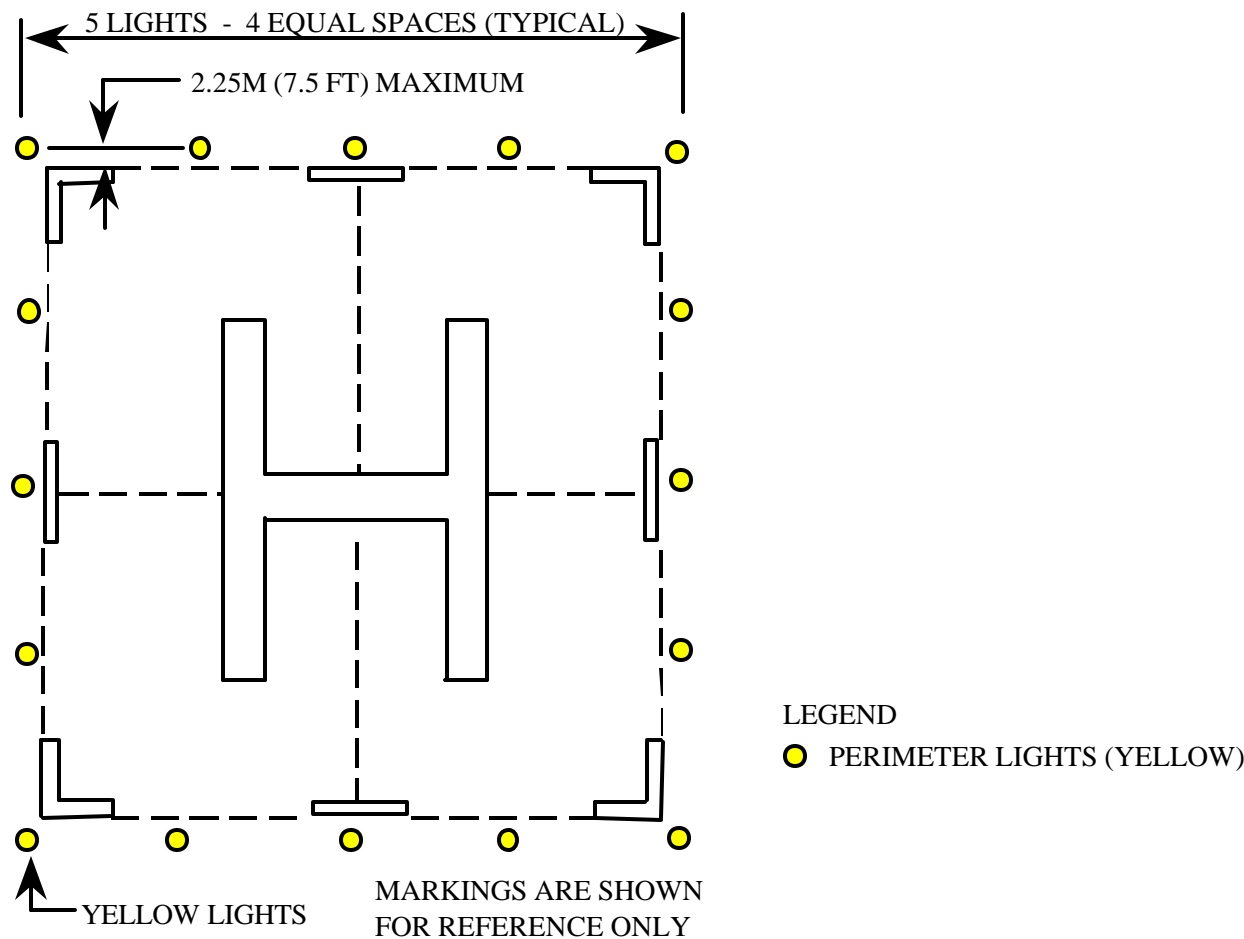
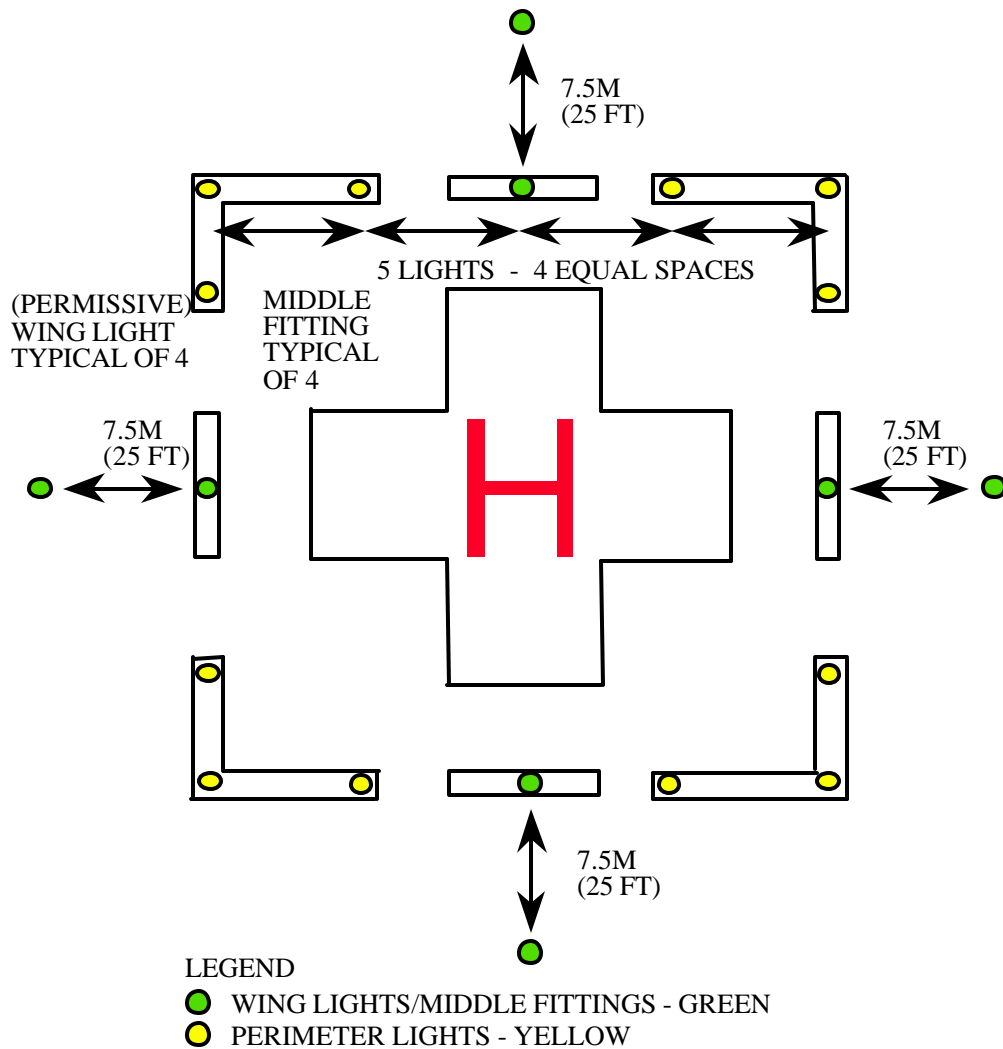


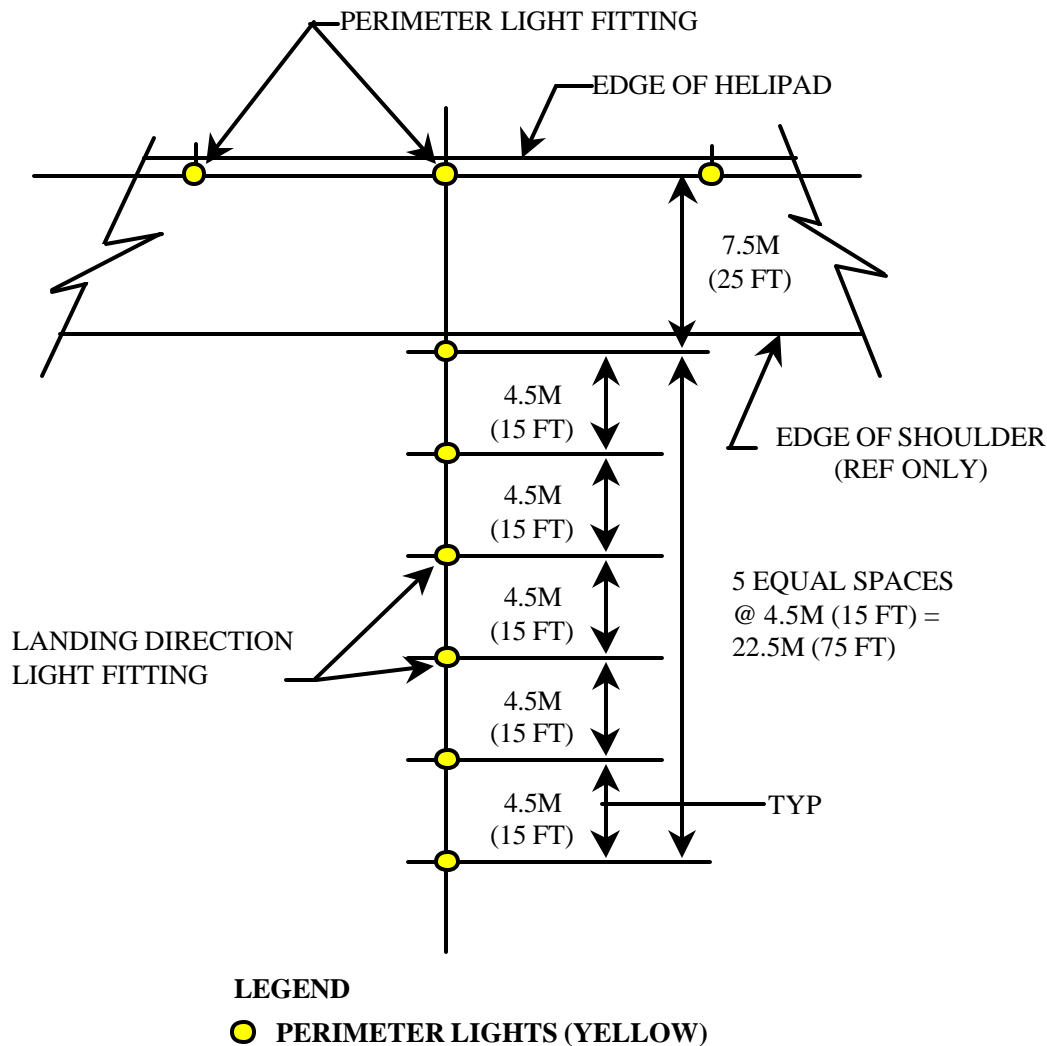
Figure 7.2. Helipad Perimeter Lights, Hospital Configuration.



NOTE: MARKINGS SHOWN FOR REFERENCE ONLY.

7.3.1. Configuration of Landing Direction Lights. Provide aviation yellow omni-directional lights in a straight line along one or more of the centerlines of the helipad, extended, and perpendicular to the perimeter lights. They must consist of six lights spaced 4.5 meters (15 feet) apart and starting 7.5 meters (25 feet) from the middle perimeter light. Locate the lights in a horizontal plane. (If a deviation is necessary, a tolerance of plus 2 percent or minus 1 percent in the longitudinal slope is permitted.) Use elevated fixtures on frangible supports, except use in-pavement fixtures when taxiing is a requirement. (See figure 7.3.)

Figure 7.3. VFR Helipad Landing Direction Lights.



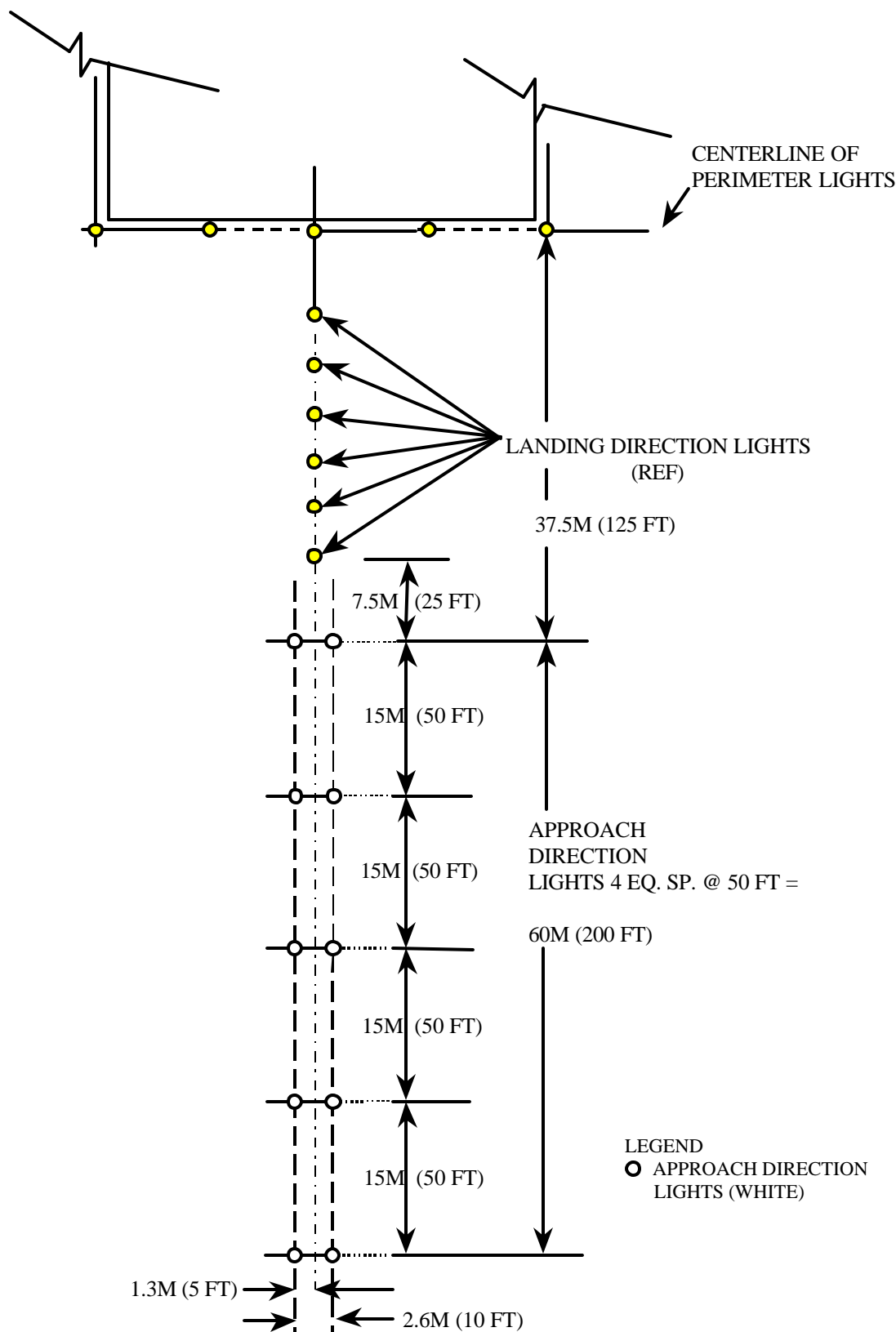
7.3.2. Purpose of Approach Direction Lights. These lights are installed whenever it has been determined that approach guidance is required in order to restrict the path of approach to the helipad or when additional guidance is needed by the pilots.

7.3.2.1. Configuration of Approach Direction Lights. Provide aviation white, omni-directional lights in two parallel rows extending out from the landing direction lights. Each row must consist of five lights spaced 15 meters (50 feet) apart, starting 37.5 meters (125 feet) from the perimeter lights and offset 1.5 meters (5 feet) either side of the extended centerline of the landing direction lights. The slope of the approach direction lights must be the same as that used for the landing direction lights. (See figure 7.4.)

7.3.3. Helipad IMC Approach Lights Category I.

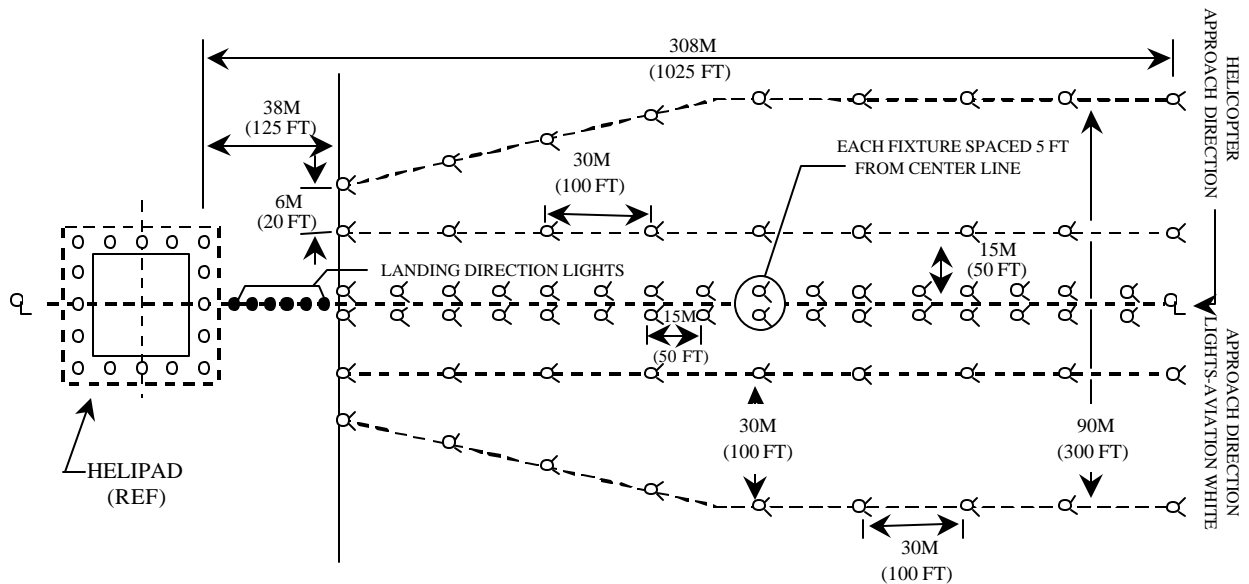
7.3.3.1. Purpose. These lights are installed whenever it has been determined that additional approach guidance is considered necessary for instrument meteorological conditions, with a decision height of 60 meters (200 feet) and an RVR of 720 meters (2,400 feet).

Figure 7.4. Helipad VFR Approach Direction Lights.



7.3.3.2. Configuration of IMC Approach Lights. The approach lighting system will be symmetrical about, and extend for the entire length of, the centerline of the helipad direction lights. This additional light system starts at the position of the approach direction lights, shown in figure 7.3, at 37.5 meters (125 feet) from the helipad and extending out to 308 meters (1,025 feet), shown in figure 7.5.

Figure 7.5. Approach Lights Category I.



- NOTES:
- (1) ○ Elevated or semi-flush omni-directional light fixture with luminous features.
 - (2) ● Normally elevated omni-directional light fixture with luminous features.
 - (3) ◡ Normally elevated uni-directional light fixtures.
 - (4) Elevated light fittings to be frangible with break-off point at top edge of base mounted plate.
 - (5) Mount light fixtures on a horizontal plane and no more than 0.45 meters (18 inches) above grade of the helipad. Where deviation of the horizontal plane is necessary, tolerance is to be +2% or -1% in the longitudinal slope. Where a slope is established for the landing direction lights, continue the same slope for the approach direction lights.
 - (6) Glide slope and setting angles:

glide slope angle	setting angle
3 degrees	6 degrees
8 degrees	11 degrees
9 degrees	15 degrees
 - (7) If multiple glide slope angles are used, use the mean value of 11 degree setting angle. Three or five progressive stages of brilliance are required for approach direction lights.
Intensities: A. Horizontal plane 20,000 CDs beam spread $\pm 7.5^\circ$.
 B. Horizontal plane 5,000 CDs beam spread $\pm 12.5^\circ$.

7.4. Refueling Area Lights. Refueling areas are class 1, division 1, group D hazardous locations as defined in NFPA 70 National Electrical Code. See paragraphs 8.4 and 8.6.5 for more information.

7.5. Helipad Floodlights:

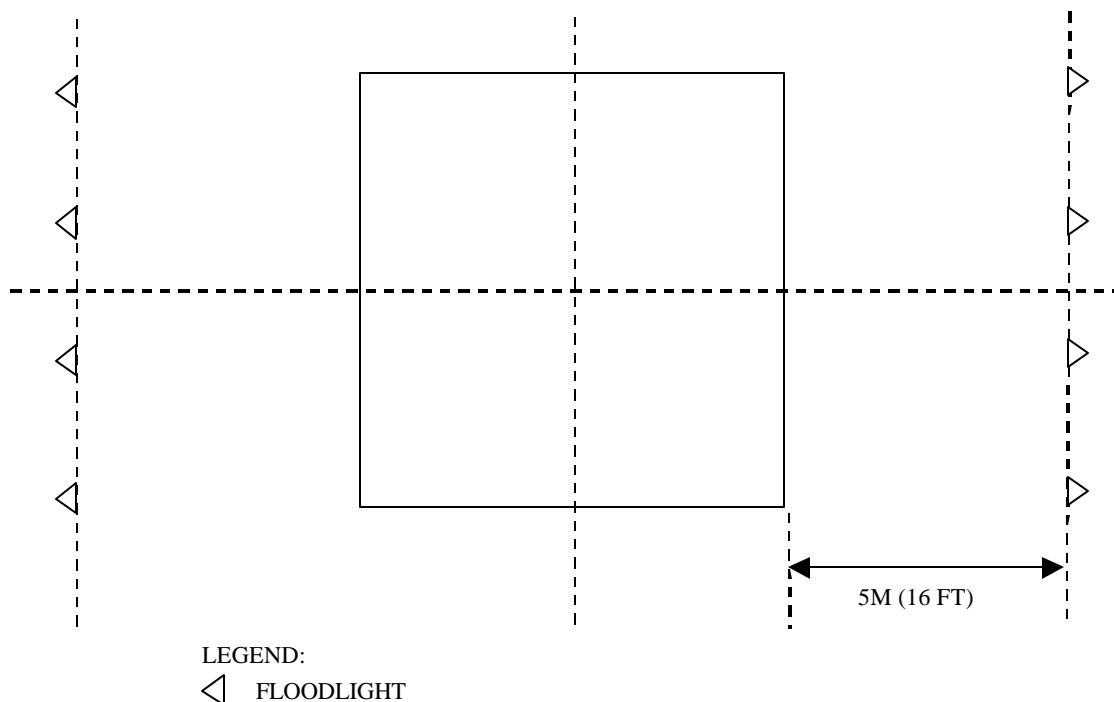
7.5.1. Purpose. Helipad floodlights may be used to illuminate the helipad surface at night to provide visual cues to the pilot for determining his height above the surface during the touchdown phase of his approach. The floodlights provide vertical illumination on the helipad surface that averages not less than two footcandles with the ratio of the average value to the darkest area not greater than 4:1. An average illumination of five footcandles is preferred. To prevent interference with or damage to an aircraft, the helipad floodlights must be as close to grade as practical and have frangible couplings. The floodlights must provide a uniform illumination

of the helipad surface. When installed, the fixtures must not permit any direct light to be visible above the horizontal. The fixture emit a narrow fan-shaped illuminating beam for which the axis of the beam must be adjustable in elevation between 1 degree up and 5 degrees from horizontal. Another purpose is for ground operations on a helipad where access to a lighted apron is not available for loading or unloading of equipment or personnel. A typical application would be a helipad located near a hospital or headquarters building.

7.5.2. Configuration of Helipad Floodlights. Locate these lights a minimum of 5.0 meters (16 feet) beyond the edges of the helipad on two opposite sides, parallel to the normal approach to the helipad. Mount the floodlights not over 0.4 meters (16 inches) above the grade of the helipad with a small obstruction light at each floodlight visible from any direction. The number of floodlights installed depends on the size of the helipad and the light output of the fixtures used. (See figure 7.6.)

7.5.3. Helipad Refueling Floodlights. Helipad refueling floodlights are class 1, division 1, group D hazardous locations, as defined in NFPA70 National Electrical Code. See paragraphs 8.4 and 8.6.5 for more information.

Figure 7.6. Helipad Floodlight Typical Configuration.



7.6. Helipad Approach Slope Indicator:

7.6.1. Purpose. A visual glide slope indicator should be provided for a helipad when obstacle clearance, noise abatement or traffic control procedures require a particular approach slope angle be flown, when the environment of a helipad provides few visual cues, or when the characteristics of a particular helicopter requires a stabilized approach path. The recommended system is Chase Helicopter Approach Path Indicator (CHAPI).

7.6.2. Justification. A Visual Glide Slope Indicator System should be provided to serve the approach whether or not there are other visual approach aids or by non-visual aids where one or more of the following conditions exist, especially at night:

7.6.2.1. Obstacle clearance, noise abatement or traffic control procedures require a particular slope to be flown.

7.6.2.2. The environment of the heliport provides few visual surface cues.

7.6.2.3. The characteristics of the helicopter required a stabilized approach.

7.6.3. Configuration. The CHAPI system consists of 2 transition light units projecting red/green/white lights. They are located forward of the helipad on the extended centerline at a distance determined in order to project an on glide path angle (usually 6 degrees) at the helipad hover point prior to touchdown. The units are positioned at approximately 6.6 meters (20 feet) apart lateral (horizontal). The CHAPI system must be constructed and mounted as low as possible and be sufficiently lightweight and frangible so as not to constitute a hazard to helicopter operations.

7.7. Helipad/Heliport Identification Beacon:

7.7.1. Purpose. A helipad beacon should be provided when long-range guidance is considered necessary and not provided by other means, or helipad identification is difficult due to surrounding lights.

7.7.2. Configuration. The beacon must contain a colored sequence of lights, double peak white flash, and a single peak green and yellow. The flash must be 10 to 15 sequences of flashes per minute. The time between each color should be one-third of the total sequence time. The beacon should not be installed within 1.6 kilometers (1 mile) of any existing airport beacon or other helipad area.

7.7.3. Construction. The beacon should be visible for a distance of 1.6 kilometers (1 mile) in 1.6 kilometer (1 mile) VMC visibility daylight, and 4.8 kilometers (3 miles) in 4.8 kilometer (3 mile) VMC at night, both from an altitude of 915 meters (3,000 feet) above ground level. The beacon should be mounted a minimum of 15 meters (50 feet) above the helipad surface. Where a control tower or control area is utilized the beacon should be no closer than 122 meters (400 feet), nor further than 1,067 meters (3,500 feet), from that area, and not located between the control tower and the helipad. The beacon will be installed so that the base is not less than 4.6 meters (15 feet) above the floor of the control tower or operations room.

7.7.4. Luminous Features. The main beam of the light should be aimed a minimum of 5 degrees above the horizontal and should not produce light below the horizontal in excess of 1,000 candelas. Light shields may be used in order to reduce the intensity below the horizontal.

7.8. Helipad Wind Direction Indicators:

7.8.1. Purpose. When utilized they will enhance operational capabilities, increase safety and reduce pilot workload during approach, hover and takeoff operations.

7.8.2. Configuration. A helipad should be equipped with at least one wind direction indicator located in a position in order to indicate the wind conditions over the final approach and take-off area. The wind indicator must be free from the effects of air flow disturbances caused by nearby objects or rotor wash. It must be visible from a helicopter in flight, in a hover, or on the movement area. Where a helipad may be subject to a disturbed air flow, additional indicators located close to the area may be necessary to indicate surface winds.

7.8.3. Construction. A wind direction indicator must be constructed in order to give a clear indication of the wind direction and a general indication of the wind speed. An indicator should be a truncated cone made of light weight fabric. The approximate minimum dimensions are 2.4 meters (8 feet) long, 0.45 meters (18 inches) diameter (large end), and 0.3 meters (1 foot) diameter (small end). The color selected must make it clearly visible and understandable from a height of at least 200 meters (650 feet) above the helipad. When practical the preferred colors should be white or orange. Where it is necessary to provide adequate conspicuity against varied backgrounds, combined colors are permitted such as orange and white, red and white, or black and white.

7.8.4. Illumination. A wind direction indicator intended for use at night must be illuminated, and have a red obstruction light mounted on the mast.

7.9. Photometric Requirements:

7.9.1. Perimeter and Landing Direction Lights. These lights must emit omni-directional aviation yellow light with intensities as follows:

2 to 10 degrees vertical	37 cd min.	67 cd average
10 to 15 degrees vertical	20 cd min.	

7.9.1.1. A 25 percent reduction in light output is permitted at structural ribs on in-pavement lights.

7.9.2. Approach Direction Lights. These lights must emit omni-directional aviation white light with intensities as follows:

2 to 10 degrees vertical	5 cd min.	125 cd average
10 to 15 degrees vertical	40 cd min.	

7.9.2.1. A 25 percent reduction in light output is permitted at structural ribs of in-pavement lights.

7.9.3. Helipad Floodlights. These fixtures must direct the entire output of the fixture below the horizontal. The average luminance must be 20 lux (2 footcandles) with a uniformity ratio (average to minimum) of not more than 4 to 1.

7.9.4. Helipad Beacons. These lights are rotating or flashing lights. They must appear to an observer at any azimuth as a series of flashing lights coded white-green-yellow. The flash duration must be 75 to 300 milliseconds. The effective intensities of white light for vertical angles above the horizontal must be:

1 to 2 degrees	12,500 cd
2 to 8 degrees	25,000 cd
8 to 10 degrees	12,500 cd

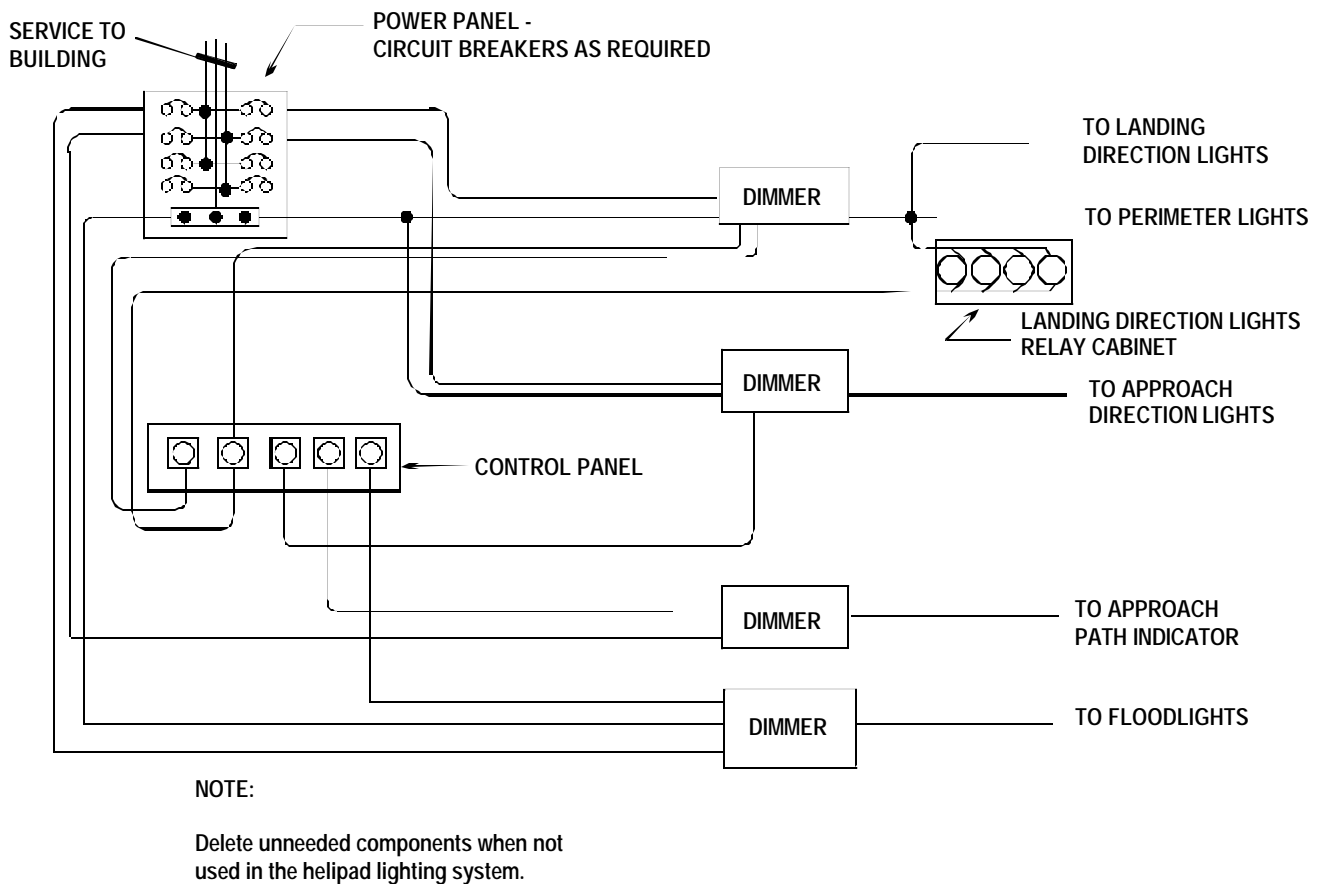
The minimum intensities of the green flashes must be 15 percent of those given for the white light, and the minimum effective intensities of the yellow flashes must be 40 percent of that given for the white light.

7.9.5. The CHAPI light units are similar to a PAPI system (see paragraph 3.7.1), with the addition of a 2.0 degree wide green sector command path. The vertical color sectors for the CHAPI system are:

above course	7.5 degrees or more	W	W
slightly high	6.5 to 7.5 degrees	W	G
on course	6.0 degrees	G	G
slightly low	4.5 to 5.5 degrees	G	R
below course	4.5 degrees or less	R	R

7.10. Power Requirements. Provide a main and an alternate power system with the capability to automatically transfer within 15 seconds from the system in use if a system fails. Typical lighting control diagrams for helipad lighting systems are shown in figures 7.7 for systems without a control tower, and in figure 7.8 with systems with a control tower.

Figure 7.7. Block Diagram Without Tower.



7.11. Control Requirements:

7.11.1. Perimeter Lights. Provide on and off control and a three-step intensity control.

7.11.2. Landing Direction Lights. Provide on and off control and a three-step intensity control. Interconnect the controls with the perimeter light controls in order to prevent operation without the perimeter lights being activated; however, they must have the capability of being independently turned off.

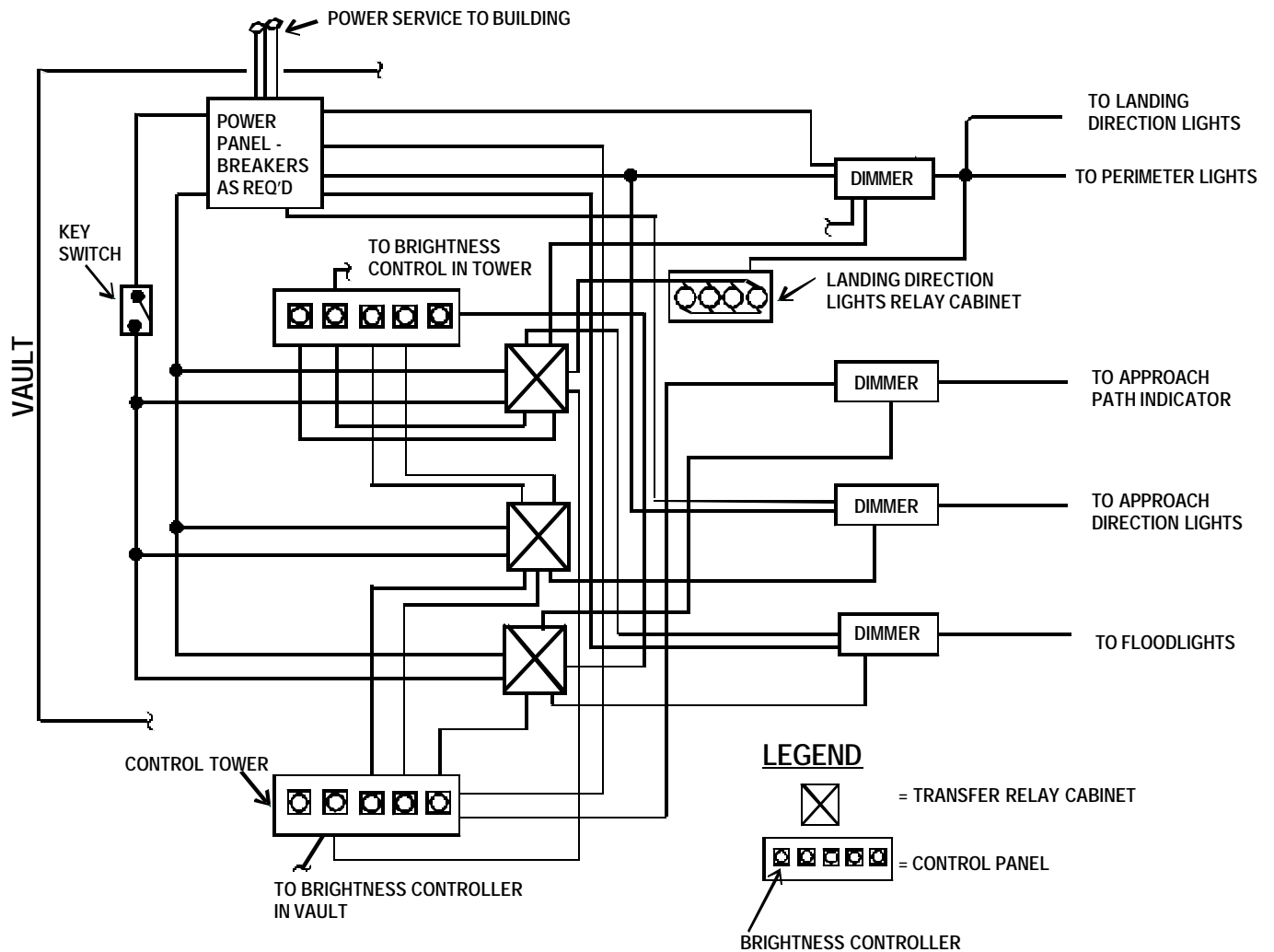
7.11.3. Approach Direction Lights. Provide on and off control and a three-step intensity control. Interconnect the controls to the landing direction light circuit in order to prevent their operation unless the landing direction lights are activated; however, they must also be capable of being turned off independently. The intensity controls may be connected to the same regulator as the landing direction lights.

7.11.4. Helipad Floodlights. Helipad floodlights require on and off control and intensity control from blackout to full intensity.

7.11.5. Helipad Beacons. Provide on and off control only.

7.11.6. CHAPI. Provide on and off control and a minimum of three-step intensity control, similar to the PAPI system.

Figure 7.8. Block Diagram With Tower.



7.12. Monitoring Requirements. There are no requirements for monitoring helipad lighting systems.

7.13. Compliance with International Standards:

7.13.1. ASCC. These standards meet the requirements of AIR STD 90/34, *Helipad and Heliport Marking and Lighting*, for helipad lighting.

7.13.2. NATO. These standards meet the requirements of STANAG 3619, *Helipad Marking*, for helipad lighting.

7.14. Equipment. See paragraph 13.14, for appropriate Helipad lighting equipment.

Chapter 8

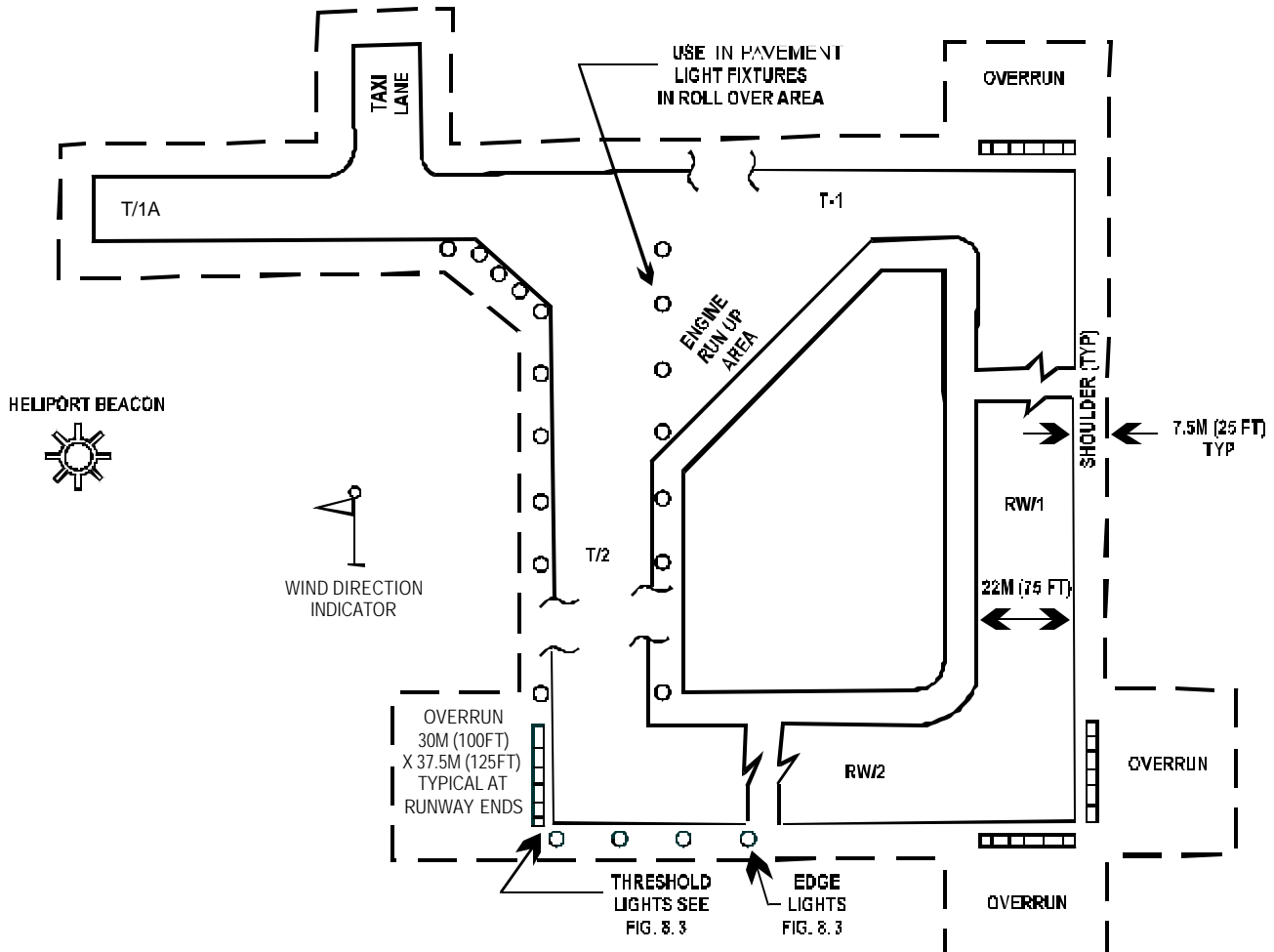
STANDARDS FOR LIGHTING HELIPORTS

8.1. General Description:

8.1.1. A helicopter runway is a prepared surface used for the approach and departure of rotary wing aircraft. It is not intended for use of fixed wing aircraft.

8.1.1.1. Heliport Runway. The design criteria set forth herein are intended to guide in designing and installing a permanent heliport lighting system utilizing elevated and in-pavement lights. Figure 8.1 shows an illustrated example of a typical heliport having two 22 meter (75 foot) wide by 480 meter (1600 foot) long intersecting runways with 12 meter (40 foot) wide connecting taxiways and 7.5 meter (25 foot) wide adjacent surface treated shoulders. Changes in the layout or design may be necessary in order to fit the requirements of a particular heliport runway installation, including a basic one runway configuration.

Figure 8.1. Layout Heliport Lighting.



8.1.2. Rotary wing landing lanes permit efficient simultaneous operations by a number of helicopters (in most cases, up to four at one time) while additional helicopters are in a designated traffic pattern.

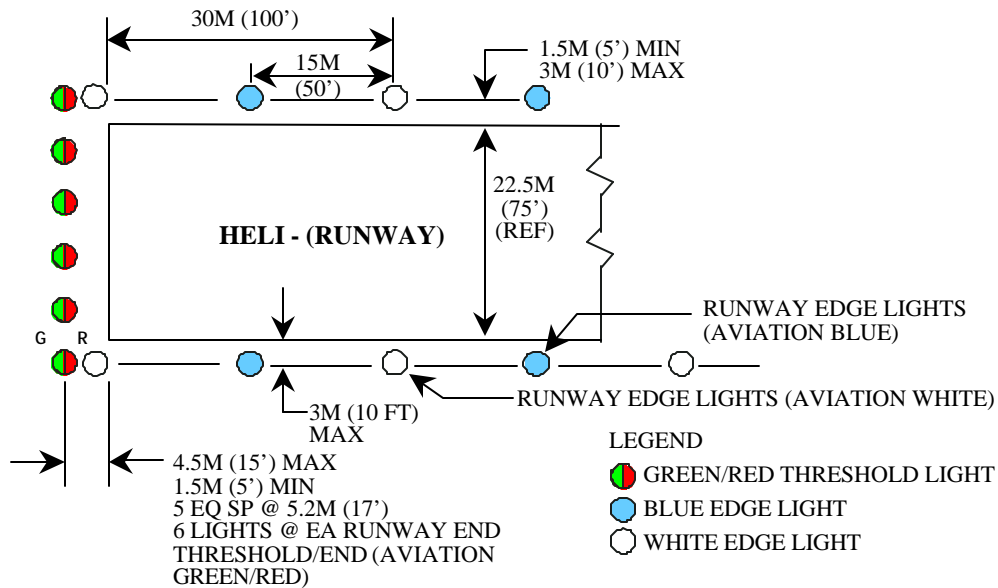
Figure 8.2. Rotary Wing Landing Lane.



8.2.2. Runway Edge Lights (Blue). When a runway is also used as a taxiway, such as two runways at 90 degree intersections, where one of the runways leads to a taxiway opposite of the approach end, aviation blue taxiway lights will be installed in addition to the white lights. The line of blue lights will be spaced at 30 meter (100 foot) maximum intervals, between the white lights (figure 8.3). Connect these blue lights to the appropriate intersecting taxiway circuit. Where only one runway is constructed, blue lights will not be

installed. All lights, both white and blue, located in runway or taxiway intersections where subjected to rollover traffic will be the in-pavement type.

Figure 8.3. Heliport Threshold and Edge Light Details.



8.2.3. Runway Threshold Lights. The line of in-pavement threshold lights must be bi-directional, 180 degrees aviation green and 180 degrees aviation red, located not less than 1.5 meters (5 feet) or more than 4.5 meters (15 feet) from the runway ends, with the lights spaced approximately 5 meters (17 feet) on centers. The outermost light of each group will be located in line with the corresponding row of runway edge lights. Each group of threshold lights will contain a minimum of six lights. When the line of runway edge lights are located at the maximum distance of 3 meters (10 feet) from the pavement edge of the runway, an additional in-pavement light will be installed in each group for a total of 7 lights in each group. The threshold lights should be controlled with the runway edge light circuit.

8.2.4. Taxiway Lights and Signs. Taxiway lighting and associated taxiway guidance signs will be in accordance with the criteria stated in Chapter 9.

8.2.5. Approach Lights. Approach light systems, when considered necessary, should be installed in accordance with the criteria cited in Chapter 7 for VFR or IFR conditions as appropriate.

8.2.6. Heliport/Helipad Identification Beacon:

8.2.6.1. Purpose. A heliport beacon should be provided when long range guidance is considered necessary and not provided by other means, or helipad identification is difficult due to surrounding lights.

8.2.6.2. Configuration. The beacon must contain a colored sequence of lights, double peak white flash, and a single peak green and yellow. The flash must be 10 to 15 sequences of flashes per minute. The time between each color should be one-third of the total sequence time. The beacon should not be installed within 1.6 kilometers (1 mile) of any existing airport beacon or other helipad area.

8.2.6.3. Construction. The beacon should be visible for a distance of 1.6 kilometers (1 mile) in 1.6 kilometer (1 mile) VMC visibility daylight, and 4.8 kilometers (3 miles) in 4.8 kilometer (3 miles) VMC at night, both from an altitude of 915 meters (3,000 feet) above ground level. The beacon should be mounted a minimum of 15 meters (50 feet) above the helipad surface. Where a control tower or control area is utilized the beacon

should be no closer than 122 meters (400 feet) nor further than 1,067 meters (3,500 feet) from that area, and not located between the control tower and the helipad. The beacon will be installed so that the base is not less than 4.6 meters (15 feet) above the floor of the control tower or operations room.

8.2.6.4. Luminous Features. The main beam of the light should be aimed a minimum of 5 degrees above the horizontal and should not produce light below the horizontal in excess of 1,000 candelas. Light shields may be used in order to reduce the intensity below the horizontal.

8.3. Rotary Wing Landing Lanes:

8.3.1. Edge Lights. The edge lights on landing lanes must be aviation white in color, located on a line 1 meter (3 feet) maximum from the edge of the full strength pavement that is designated for lane use, as illustrated in figure 8.3.

8.3.2. The longitudinal spacing must be uniform and not greater than 45 meters (150 feet) and not less than 30 meters (100 feet) on each side of the landing lane. When two or more landing lanes are parallel, or in close proximity to each other, the lane edge lights will be configured so they will not line up to create a false runway orientation configuration when helicopters are approaching from perpendicular or oblique angles to the landing lane centerlines. The height of the light fixture will not exceed 0.3 meters (14 inches) above grade except, when snow accumulations of 0.3 meters (12 inches) will be frequent, the edge light height may be increased to 0.6 meters (24 inches) above grade. The light fixtures will be mounted on frangible posts of not more than 2 inches in diameter. Each landing lane edge light system will be equipped with a 5-step constant current regulator which permits control from blackout to full intensity. For additional information see Chapter 13, or refer to FAA AC 150/5340-24.

8.3.3. Threshold/End Lights. Combination threshold and lane end light fixtures must be located on a line perpendicular to the extended centerline of the landing lanes. The line of lights must not be less than 0.6 meters (2 feet) nor more than 3 meters (10 feet) outboard from the designated threshold of the landing lane. The lights must consist of four groups of two lights, 2 meters (6 feet) on center, symmetrically located perpendicular to the extended centerline of the landing lanes (see figure 8.2).

8.4. Refueling Area Lights. A hazardous location exists within 15 meters (50 feet) of an aircraft fuel inlet or fuel system vent and within 19 meters (63 feet) of an aircraft direct fuel outlet/fuel-dispensing nozzle. Refueling areas are Class 1, Division 1, Group D hazardous locations as defined in National Fire Protection Association NFPA 70 National Electrical Code. The light fixture assemblies and associated wiring must be suitable for installation in the hazardous location. Refer to FAA AC 150/5345-39, *Runway and Taxiway Centerline Retroreflective Markers*, for the use of retro-reflective markers.

8.5. Hoverlane Lighting Systems:

8.5.1. A hoverlane is a designated aerial traffic lane (air taxi) for the directed movement of helicopters between a helipad or hoverpoint and the servicing and parking area of a heliport or airfield.

8.5.2. Hoverlane lighting systems will consist of a single row of alternating aviation green and yellow taxiway light fixtures located along the centerline of the hoverlane. Elevated fixtures will be installed and will be spaced nominally 12.7 meters (50 feet) on center for long straight sections, and mounted on metal light base fittings. For curves, fixtures will be spaced nominally 6.3 meters (25 feet) on centers. When hoverlanes terminate adjacent to hanger access aprons or boundaries of other areas not intended for own-power operation, the desirable limit of helicopter travel along hoverlanes toward such areas will be indicated by three lighting fixtures emitting aviation red light. Two red hoverlane limit lights will each be installed on opposite sides of, and approximately 3.8 meters (15 feet) from, the hoverlane centerline. The third light, forming a line of three such

lights perpendicular to the alternating aviation green and yellow hoverlane lights, will be located in line with the alternating aviation green and yellow hoverlane lights. Red hoverlane limit lights will provide uni-directional guidance by use of a combat-type hood attached to a taxiway light fitting. The row of alternating aviation green and yellow hoverlane lights described above will terminate approximately 6.3 meters (25 feet) from the red limit lights, outward from the apron or boundary. Hoverlane limit light mountings and types will be as for the alternating aviation green and yellow hoverlane lights described above. Hoverlane turnoffs to individual parking pads will be indicated by aviation green and yellow hoverlane lights beginning approximately 6.3 meters (25 feet) from and perpendicular to the hoverlane, installed on nominal 6.3 meter (25 foot) centers. The line of hoverlane turnoff lights will terminate approximately 6.3 meters (25 feet) from the edge of the parking pad nearest the hoverlane. The limit of helicopter travel from the hoverlane toward the pad, along the turnoff, will be indicated by two parking pad limit lights, which will be located approximately 5 meters (20 feet) beyond the pad, 3.8 meters (15 feet) apart, and perpendicular to the turnoff light line. Parking pad limit lights will emit aviation red light, and will provide uni-directional guidance with a combat-type hood, attached to a taxiway light fitting with red lens. All hoverlane limit and parking pad limit lights will be provided with brightness control and circuited separately, as a group, from other lights. Hoverlane lighting will not be installed in the rigid pavement area of mass parking aprons.

8.6. Lighting Equipment:

8.6.1. Elevated Runway and Landing Lane Edge Lights. Elevated runway edge lights will be omnidirectional, medium intensity, FAA type L-861. The lamp for this light will be approximately 30 watts, 6.6 amperes, as recommended by the manufacturer (figure 13.12).

8.6.2. In-pavement Runway Lights. In-pavement runway lights will be medium intensity, FAA type L-852 E (figure 13.13). Where rollover is anticipated on a runway or taxiway, use in-pavement light fixtures of the appropriate color.

8.6.3. Threshold Lights. In-pavement threshold lights will be FAA type L-852E. A 180 degree aviation green, 180 degree aviation red filter, will be supplied with the light fixture.

8.6.4. Runway Blue Lights. Elevated and in-pavement lights will be aviation blue, FAA type L-861.

8.6.5. Refueling Area Lights. Fixture assembly must meet the requirements Underwriters Laboratories (UL) test and approval requirements as stated in UL 844 for class 1, division 1, group D hazardous locations as defined in NFPA 70. The fixture assembly will include a light fixture, frangible coupling, power disconnect switch that will kill power if the frangible mount is broken, and a junction box. As an alternative, use the light fixture assemblies and associated wiring that are intrinsically safe and meet Underwriters Laboratories (UL) test and approval requirements as stated in UL 913 for class 1, division 1, group D hazardous locations as defined in NFPA 70.

8.6.6. Runway and Taxiway Signs. When operational requirements consider it necessary to install informational mandatory guidance signs, see Chapter 5 for guidance. Runway and taxiway signs are designated in two groups: mandatory signs are white letters on a red background, and information signs are black letters on a yellow background.

8.6.7. Auxiliary Lighting. For auxiliary lighting such as floodlights, protective lighting and intensities, see paragraph 10.4.

8.7. Power Requirements. Runway lighting systems will be supplied through interleaved series circuits served by constant current regulators. The regulators are available in various load capacities and output current values, and have brightness controls so that the light output can be adjusted to suit the visibility conditions.

8.7.1. Circuit Criteria. The number and type of regulators required will be determined by the circuit length. Address power losses from cable lengths to and from the lighting vault to the lights and the isolation transformer loss when designing the lighting system.

8.7.2. Cable Connectors, Plug and Receptacles. See Chapter 13.

8.7.3. Cables used for series circuit. Will be No.8 or No. 6 AWG 1/C stranded copper, 5,000 volt, cross-linked polyethylene (XLP). See paragraph 13.8.7. and FAA AC 150/5345-7, *Specification for L-824 Underground Electrical Cable for Airport Lighting Circuits*. Use No. 6 AWG cable on all 20 ampere circuits.

8.7.4. Isolation transformers. See paragraph 13.8.9 for information.

8.8. Control Requirements. The heliport lighting control system is an integral part of the control system for all heliport lighting facilities. The function of this portion of the control system is to energize and de-energize the selected runway lighting systems, and to control the brightness of the lights. All lights will be controlled from the control tower and from the lighting equipment vault. The circuits will be provided and connected as indicated in figure 8.4, with the runway/taxiway combination control panels and associated equipment connected to permit separate control of each heliport lighting system, independent of each other, and permit simultaneous control of the taxiway circuits in combination. Coordinate the need to interlock the lighting on intersecting runways so that both runway lighting systems cannot be energized simultaneously. Taxiway circuit T-1A will be connected with separate individual control in order to permit flexibility in the operation of the runway and taxiway lights either singly, in combination, or simultaneously, as required for the heliport operations by the control tower operator. The layout will also allow for future changes, and expansion in the methods of operation with a minimum of expense and interruption of service.

8.8.1. Provide edge lights and threshold lights with 3 intensities as follows:

Intensity Step	Percent of Full Intensity
1	10%
2	20%
3	100%

If required by the operations community, for compatibility with night vision goggles, the edge lights and threshold lights may be provided with 5 intensities as follows:

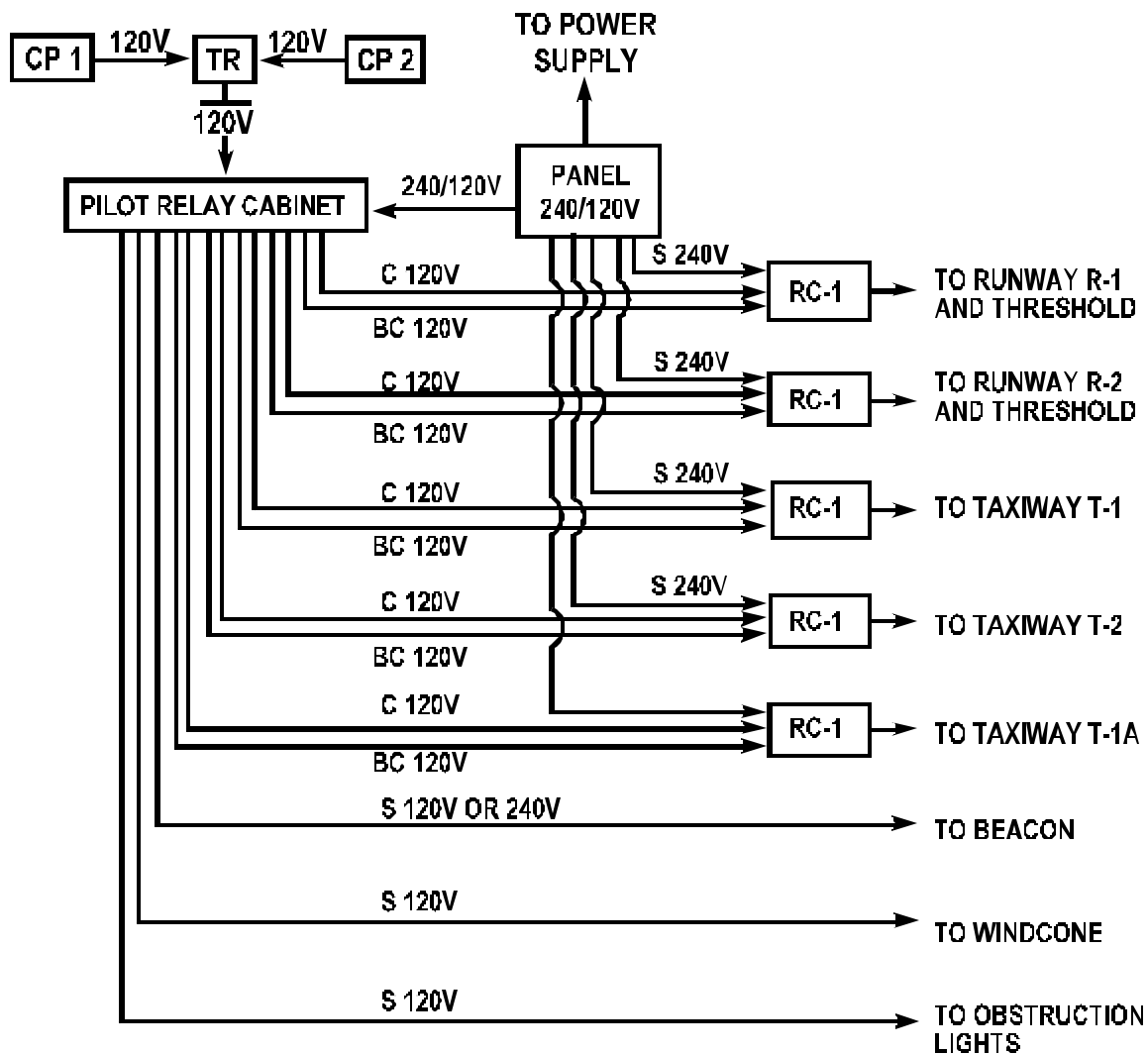
Intensity Step	Percent of Full Intensity
1	0.16%
2	0.8%
3	4.0%
4	20%
5	100%

8.8.2. Basic Operations. The initial sequence of operations of the heliport lighting circuits anticipated is such that when helicopters are utilizing the night landing facilities of the heliport: the blue taxiway lights (circuits T-1 and T-2) will be turned on, but only the white edge lights and green/red threshold lights (circuits R-1 or R-2) of the runway in use will be turned on. Use figure 8.4 as a reference.

Example: White edge lights, R-1, ON
 Threshold lights, R-1, ON
 Blue edge lights, R-2, ON
 Blue edge lights, T-2, ON
 Blue edge lights, T-1A, ON
 All other taxiway/runway lights, OFF

The above example will allow a helicopter to land on R1, taxi on R2, taxi on T2, and proceed to a designated area via T-1A.

Figure 8.4. Block Diagram Typical System.



LEGEND

CP-1 - Control Point Primary (Control Tower)
 CP-2 - Control Point Alternate (Vault)
 RC-1 - Regulator
 TR - Transfer Relay
 BC - Brightness Control
 C - Control
 S - Supply

NOTE: Electric power source, main service switch, emergency generator and transfer switch and main distribution panel not shown. Installation of these items will be designed to meet local conditions.

8.9. Monitoring Requirements. There are no requirements for monitoring the lighting systems on heliports or rotary landing lanes.

8.10. Compliance with International Standards:

8.10.1. ASCC. There are no air standards for heliports or landing lanes.

8.10.2. NATO. There are no standards for heliports or landing lanes, however STANAG 3619 makes reference to the US Army criteria for IFR approach lighting.

8.11. Equipment. See Chapter 13 for lighting equipment.

Chapter 9

STANDARDS FOR AIRFIELD SIGNS AND MARKERS

9.1. General:

9.1.1. Signs and markers provide important guidance and control for the safe and efficient surface movement of aircraft on an airfield. Proper signing provides information on location, direction, destination, mandatory holding positions, important boundaries, and other information. Additionally, runway distance markers provide to the pilot the remaining distance on a runway for landing and take-off operations.

9.1.2. The intent of this standard is to provide signing consistent with current FAA and ICAO requirements and standards, including: FAA AC 150/5340-18, *Standards for Airport Sign Systems*, including all current Sign and Marking Supplements (SAMS); FAA AC 150/5345-44, *Specification for Runway and Taxiway Signs*; and ICAO Annex 14, Chapter 5, *Visual Aids for Navigation*. The signing criteria in this chapter and in the references above should be applied at all airfields to the extent that they do not conflict with any special local requirements.

9.1.3. Components of a Sign System. The following types of signs, discussed more below, are basic components of a sign system for an airfield:

9.1.3.1. Mandatory Signs. Red sign with white legend, indicating mandatory holding positions for runways, ILS critical area boundaries, and certain other mandatory instructions to pilots. (FAA Type L-858R)

9.1.3.2. Taxiway Guidance and Information Signs. Yellow sign with black legend, indicating direction, destination, runway exit, clear of a boundary, or other information. (FAA Type L-858Y)

9.1.3.3. Location Signs. Yellow legend and border on black background, indicating the surface on which the aircraft is operating. While primarily indicating taxiway location, these also may be used to indicate runway location at potentially confusing areas. (FAA Type L-858L)

9.1.3.4. Sign Arrays. Signs are often established as a sign array with several messages. For example, a location sign may be grouped with a mandatory holding position sign or with one or several direction sign messages as a sign array. However, not all types of signs may be grouped together.

9.1.3.5. Runway Distance Markers. White legend on black background, with a single number indicating in multiples of 1,000 feet the remaining runway distance for pilots during takeoff and landing operations. Metric measure is not used for this sign. (FAA Type L-858B)

9.1.3.6. Arresting Gear Markers. Yellow circle on black background, identifying the location of arresting system cables on the runway. (Similar to FAA Type L-858B)

9.1.3.7. Other Signs. Other signs serving special situations may be used, provided they do not conflict with the sign standards, or have the potential for confusing ground traffic with respect to standard signing. Vehicle control signs conforming to the Manual of Uniform Traffic Control Devices (MUTCD) (Air Force use AFPAM 32-1097, *Sign Standards Pamphlet*), such as the standard octagonal stop sign, may be used at locations that would apply only to vehicles.

9.2. Mandatory Signs:

9.2.1. Purpose. Mandatory signs provide instruction that must be followed. They denote an entrance to a runway or critical area, or other situation such as a no-entry location. At controlled airfields (with active tower), aircraft and vehicles are required to hold unless cleared by air traffic control. At uncontrolled airfields, the intent is that traffic may only proceed beyond the sign after appropriate precautions are taken. Examples of mandatory sign messages are shown in figure 9.1.

Figure 9.1. Typical Mandatory Signs.



RUNWAY HOLD SIGN
(AT END INTERSECTION)



RUNWAY HOLD SIGN
(AT INTERMEDIATE INTERSECTION)



HOLD SIGN AT ILS
CRITICAL AREA

ILS



APPROACH HOLD SIGN
(ON INTERSECTING TAXIWAY INTERSECTION)



NO ENTRY SIGN

NOTE: ALL SIGNS ARE FAA TYPE L-858R, WITH WHITE LEGEND ON RED BACKGROUND, MEETING FAA AC 150/5345-44, TYPICALLY SIZE 3, STYLE 2 OR 3.

AN ARROW MAY BE USED TO HELP IDENTIFY RUNWAYS AT TAXIWAY/RUNWAY/RUNWAY INTERSECTIONS. FOR ADDITIONAL GUIDANCE, SEE FAA AC 150/5340-18.

9.2.2. Installation. Mandatory signs are installed on the left-hand side at taxiway/runway intersections, runway/runway intersections, ILS critical areas, runway approach zones, no entry areas.

9.2.2.1. At some locations, signs should be installed on both sides of runways and taxiways. This includes: runways more than 45 meters (150 feet) in width; runways of any width which are used for “land and hold short” operations; or taxiways that are 45 meters (150 feet) or greater in width.

9.2.2.2. Hold signs should be collocated with hold markings and located at a distance from the intersecting runway to meet the clearance requirements of the intersecting runway or ILS critical area. Coordinate this distance with Airfield Management and Flight Safety Offices. On taxiways in approach areas, the sign is installed where an aircraft would cross the runway safety area or penetrate the required airspace for approaches and departures.

9.2.2.3. Mandatory signs may be FAA Size 1, 2 or 3. Size 3 signs are recommended for Category I facilities and higher. From edge of runway or taxiway, locate a Size 3 sign 11-18 meters (35-60 feet), a Size 2 sign 6-11 meters (20-35 feet), and a Size 1 sign 3-6 meters (10-20 feet). The distance indicated is to the inside edge of a sign. Signs are oriented perpendicular to the runway or taxiway centerline, but may be canted up to 15 degrees to increase visibility if the sign is not a double-face sign. At locations where large wingspan aircraft operations are common, place signs far enough from taxiway edges to allow required wingtip clearance.

9.2.2.4. Mandatory signs may be grouped in an array with a location sign, or may have a location sign or a Safety Area/Obstacle Free Zone (OFZ) or ILS Critical Area boundary sign on the back face. Direction or destination signs may not be grouped with a mandatory sign. In an array, the location sign is always positioned outboard of the mandatory sign. See FAA 150/5340-18 and associated SAMS for further guidance on grouping several sign messages in an array.

9.2.3. Characteristics. See Chapter 13 and FAA 150/5345-44 for additional characteristic information.

9.2.3.1. Message. Signs are either single face or double face, internally lighted, with retro-reflective message faces that meet the color and reflectivity requirements of ASTM D 4956, *Sheeting Retroreflective, for Traffic Control*, Type I Sheeting. The spacing, stroke, and shape of legend characters, numerals, and symbols must be in accordance with FAA AC 150/5345-44, Appendices 1 and 2.

9.2.3.2. Dimensions. See FAA 150/5345-44 Tables 1 and 2 for sign and legend height dimensions. As an example, an FAA Size 3 sign has a legend height of 460 millimeters (18 inches), legend panel height of 760 millimeters (30 inches), overall sign mounting height of 910-1070 millimeters (36-42 inches), maximum overall sign length of 2134 millimeters (170 inches), and minimum sign length of 1067 millimeters (42 inches).

9.2.3.3. Electrical. Lighted signs can be powered from a 120-volt AC power source (FAA Style 1), a 3-step 6.6 amperes series circuit (FAA Style 2), a 5-step 6.6 or 20 amperes series circuit (FAA Style 3), or a dedicated 5.5 amperes series circuit (FAA Style 5). Unlighted signs are FAA Style 4. For multiple-step series lighting circuits, the sign must provide luminance within the allowable ranges over all the intensity steps. Signs are connected to series circuits with an isolation transformer, and must be provided with breakaway cable connectors installed within the frangible coupling portion of the sign’s mounting. Styles 2, 3, and 5 signs must be compatible with all FAA L-828/829 constant current regulators.

9.2.3.4. Photometrics. The average sign luminance, as determined in accordance with FAA AC 150/5345-44, must be as follows for all intensity steps: white legend, 10 to 30 foot-lamberts, with 16 to 30 foot-lamberts at the 2 highest intensity steps; red background, 2.9 to 8.8 foot-lamberts. Further, the ratio of average luminance between white legend and red background must be no greater than 10:1 and no less than 5:1.

9.2.4. Power and Control. Lighted mandatory signs are typically connected to the runway edge lighting series circuit for the associated runway. In this way they are turned on and off with the runway lighting. If the signs are circuited separately or otherwise not connected to the runway edge lighting, they should be interlocked together in such a way so as to turn on and off with the runway edge lighting.

9.3. Taxiway Guidance and Information Signs:

9.3.1. Purpose. Taxiway guidance signs include direction signs, destination signs, other informational signs, and boundary signs. Direction signs indicate the direction of taxiways leading out of an intersection, and are installed at runway exits, taxiway intersections, and other locations. Destination signs indicate the general direction to a remote location. For example, outbound destination signs are used to identify the direction to takeoff runways, while inbound destination signs are used to indicate direction to major areas such as aprons, fueling points, and other locations. Both direction and destination sign messages include an arrow. Boundary signs indicate important boundaries such as ILS critical areas and runway approach areas. Typically boundary signs are not installed at military airfields, although they are often used at joint military/civil airfields. Other signs are used to provide specific information such as noise abatement procedures, check points, and others. Examples of guidance sign messages are shown in figure 9.2.

9.3.2. Installation. Runway exit signs are installed on the side of the runway exit prior to the intersection. All other signs are installed on the left side of the taxiway unless special circumstances require otherwise.

9.3.2.1. A direction sign is installed prior to an intersection. Typically they are installed at the point of tangency of the taxiway intersection, but not closer than required for the safe turning of aircraft. Minimum distances from the intersecting taxiway can be found in FAA AC 150/5340-18 Table 3.

9.3.2.2. Destination signs are not always needed where direction signs are used, but are helpful where direction signs alone do not adequately guide a pilot to the desired destination. They may be particularly helpful at uncontrolled airfields. Destination signs should be located so where they will not cause confusion with direction signs, and are subject to the same minimum distances from intersecting taxiways. See FAA AC 150/5340-18 for additional guidance.

9.3.2.3. An ILS Critical Area boundary sign is installed at the boundary limit to indicate where it is clear of the ILS Critical Area. The Air Force will use “INST” instead of “ILS” for the instrument holding position/critical area boundary when more than just the ILS is available, such as PAR, MLS, or GPS.

9.3.2.4. TACAN Checkpoint signs are provided when an airfield has a TACAN system and provides information for the pilot who verifies the operation of the navigational aid in the aircraft before takeoff. The sign includes information on the type of navigational aid, identification code, radio channel, magnetic bearing, and the distance in nautical miles to the transmitting antenna from the checkpoint marking. The sign is positioned so it will be visible to the pilot of the aircraft properly positioned on the checkpoint marking.

9.3.2.5. Altimeter Checkpoint Sign. When runway end elevations differ by 7.6 meters (25 feet) from the published field elevations, an “Altimeter Check Point Sign” is required. Coordinate with TERPS to verify runway and field elevations. This sign should be combined and/or collocated with the TACAN Checkpoint Sign when available, as the same height and lettering requirements apply. Lettering may be abbreviated as follows: “ALT CHK PT - ELEV: XXXX,” where “XXXX” is the elevation in feet above mean sea level.

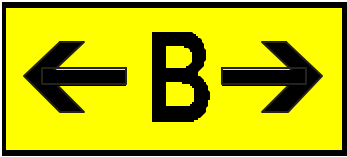
9.3.2.6. Other informational signs have messages and are located as determined by operations.

9.3.2.7. Guidance and information signs may be FAA Size 1, 2 or 3. Size 3 signs are recommended for Category I facilities and higher. Locate a Size 3 sign 11-18 meters (35-60 feet), a Size 2 sign 6-11 meters (20-35 feet), and a Size 1 sign 3-6 meters (10-20 feet) from edge of runway or taxiway. The distance indicated is to the inside edge of a sign. Signs are oriented perpendicular to the runway or taxiway centerline, but may be canted up to 15 degrees to increase visibility if the sign is not a double-face sign.

Figure 9.2. Typical Taxiway Guidance and Information Signs.



RUNWAY EXIT SIGN



DIRECTION SIGNS



OUTBOUND DESTINATION SIGNS



INBOUND DESTINATION SIGNS



TACAN CHECKPOINT SIGN

NOTE: ALL SIGNS ARE FAA TYPE L-858Y, WITH BLACK LEGEND ON YELLOW BACKGROUND, MEETING FAA AC 150/5345-44, TYPICALLY SIZE 3, STYLE 2 OR 3.

9.3.2.8. Direction signs other than runway exit signs may be grouped in an array with a location sign. Destination signs may not be grouped with other signs, but may be on the back of another sign in which case it

would be on the right hand side for traffic. See guidance in paragraph 9.5 for conventions on sign arrays. See FAA 150/5340-18 and associated SAMS for further guidance on grouping several sign messages in an array.

9.3.3. Characteristics. See Chapter 13 and FAA 150/5345-44 for additional characteristic information.

9.3.3.1. Message. See paragraph 9.2.3.1.

9.3.3.2. Dimensions. See paragraph 9.2.3.2. For TACAN Checkpoint signs, the character height must not be less than 15 centimeters (6 inches) or more than 22 centimeters (9 inches), and the stroke width not less than 2 centimeters (1 inch). The height of a TACAN Checkpoint sign must not be more than 0.8 meters (32 inches) and the length not more than 1.8 meters (72 inches), with the maximum sign elevation above the taxiway edge not more than 1 meter (40 inches). The TACAN Checkpoint sign should not be located less than 15 meters (50 feet) from the taxiway edge.

9.3.3.3. Electrical. See paragraph 9.2.3.3.

9.3.3.4. Photometrics. The average sign luminance, as determined in accordance with FAA AC 150/5345-44, must be as follows for all intensity steps: yellow background, 10 to 30 foot-lamberts, with 16 to 30 foot-lamberts at the 2 highest intensity steps.

9.3.4. Power and Control. Runway exit signs are connected to the runway edge lighting series circuit. Other lighted guidance signs as well as information signs are typically connected to taxiway edge lighting circuits. This configuration permits the signs to be turned on and off with the respective runway or taxiway lighting.

9.4. Location Signs:

9.4.1. Purpose. Location signs identify the taxiway or runway on which the aircraft is located. Examples of location sign messages are shown in figure 9.3.

9.4.2. Installation. Location signs are typically installed on the left side of a taxiway, but also may be on the right side if this helps visibility. Often taxiway location signs are part of a sign array, hence may be together with a mandatory hold sign or a guidance direction sign (although not with a runway exit sign). Runway location signs may be installed on runways where two runways are in proximity, which could create confusion, and are located to clearly indicate the runways for pilots. Runway location signs are not part of a sign array, and contain the runway designation only for the one runway end.

9.4.2.1. Location signs are subject to the same siting criteria as the direction and information signs in paragraph 9.3. Taxiway location signs may be part of a direction sign array, or may be stand-alone between taxiways where it would be helpful to reinforce pilot information as to location.

9.4.2.3. Location signs may be FAA Size 1, 2 or 3. Size 3 signs are recommended for Category I facilities and higher. Locate signs as indicated in paragraph 9.3.2.6.

9.4.2.4. A location sign may be grouped in a sign array. With mandatory signs, the location sign should always be positioned outboard. With a direction sign array, the location sign is placed so that all turns to the left would be located to the left of the location sign, and all turns to the right or straight ahead would be located to the right of the location sign. An exception is when only two taxiways intersect and the direction sign indicates the crossing taxiway with arrows both ways, in which case the location sign is positioned to the left.

9.4.2.5. Location signs are not always needed in conjunction with a direction sign. The need is determined from evaluating the complexity of the intersection layout, distance from the last location sign, complexity of prior intersections, traffic flow, and typical conditions under which the intersection is used. Do not include a location sign as an array with a destination sign or other information sign. See guidance in paragraph 9.5 for conventions on sign arrays. See FAA 150/5340-18 and associated SAMS for further guidance on grouping several sign messages in an array.

Figure 9.3. Typical Location Signs.



TAXIWAY LOCATION SIGN



RUNWAY LOCATION SIGN



POSITION OF A LOCATION SIGN IN AN
ARRAY OF DIRECTION SIGNS

ILS

OUTBOARD
SIDE



TAXIWAY
→

LOCATION SIGN COLLOCATED
WITH A RUNWAY HOLD SIGN

NOTE: LOCATION SIGNS ARE FAA TYPE L-858L,
WITH YELLOW LEGEND AND BORDER ON BLACK
BACKGROUND, MEETING FAA AC 150/5345-44,
TYPICALLY SIZE 3, STYLE 2 OR 3.

9.4.3. Characteristics. See Chapter 13 and FAA 150/5345-44 for additional characteristic information.

9.4.3.1. Message. See paragraph 9.2.3.1.

9.4.3.2. Dimensions. See paragraph 9.2.3.2.

9.4.3.3. Electrical. See paragraph 9.2.3.3.

9.4.3.4. Photometrics. The average sign luminance, as determined in accordance with FAA AC 150/5345-44, must be as follows for all intensity steps: yellow legend and border - 10 to 30 foot-lamberts, with 16 to 30 foot-lamberts at the 2 highest intensity steps.

9.4.4. Power and Control. Runway location signs are connected to the runway edge lighting series circuit. Taxiway location sign are typically connected to taxiway edge lighting circuits similar to taxiway guidance and information signs in paragraph 9.3.

9.5. Signing Conventions for Airfield Signs:

9.5.1. There is no standard configuration for signing that applies to all airfields. In laying out signing for an airfield, first conduct a thorough study of the runway and taxiway layout drawings with local traffic controllers and the operational group using the airfield. Signs are not necessarily needed at all potential locations on an airfield, and judgment must be made based on standards, other guidance, and operational need in order to provide clear, non-conflicting direction to taxiing pilots. It is recommended that the appropriate local engineering function maintain, and update as required, a master sign plan for the complete airfield.

9.5.2. Following are general signing conventions to be followed for all airfields:

9.5.2.1. Signs should always be placed on the left side of a taxiway as seen by the pilot of approaching aircraft. Exceptions are:

9.5.2.1.1. Where signs are placed on both sides of a surface (for example, at wide throat entrances to intersections).

9.5.2.1.2. Where a sign may be placed on the back of a left-handed sign for traffic in the other direction (such as a location or boundary sign on the back of a mandatory hold sign).

9.5.2.1.3. Where a destination sign might be placed at the top of a “T” at a “T” intersection.

9.5.2.1.4. Where necessary for clearance requirements.

9.5.2.1.5. Where it is impractical to install on the left because of terrain or conflicts with other objects.

9.5.2.2. If signs are installed on both sides of a taxiway at the same location, the sign faces should be identical. An exception is for holding position signs, where a location sign in the array should always be outboard of the mandatory sign.

9.5.2.3. All direction signs have arrows. Arrows on signs should be oriented to approximate the direction of the turn. Each designation on an array of direction signs should be accompanied only by one arrow. An exception is when an intersection has only two taxiways where it is permissible to have the designation of the cross taxiway with arrows both ways.

9.5.2.4. Location signs are typically included as part of a direction sign array. The location sign is placed so that the designations for all turns to the left are on the left of the location sign, and all turns to the right or straight ahead (if used) are on the right of the location sign. A location sign installed together with a mandatory sign is always located outboard of the mandatory sign.

9.5.2.5. A direction sign with an arrow indicating a taxiway continues straight ahead (25 degrees or less change in alignment) is usually not needed, unless the designation of the taxiway changes at the intersection.

9.5.2.7. Information signs should not be collocated with mandatory, location, direction, or destination signs.

9.5.2.6. Each designation and its associated arrow in a direction sign array should be delineated from the other designations in the array by a black vertical border. Where appropriate, a location sign may provide this delineation.

9.5.2.8. Destination signs are never grouped with other signs in a sign array. Destination signs may be installed on the back side of a direction sign on the far side of an intersection when the destination referred to is straight ahead. At intersections or junctions of runways, taxiways, or runways and taxiways, where there

are alternate routes to a particular destination from a given direction of travel, indicate only one route on the destination sign.

9.5.2.9. Outbound Destination Signs. Mark outbound routes from their beginning to their termination point with destination signs showing the appropriate runway(s) designation. Outbound routes usually begin at the entrance of a taxiway from an apron area; its termination point is the takeoff end of the appropriate runway. Outbound destination signs may show more than one runway destination number if the direction of travel on a taxiing route is the same to all the runway destinations shown on the sign. In such cases, separate any pair of runway designation numbers by a circular dot.

9.5.2.10. Inbound Destination Signs. Mark inbound routes from their beginning with destination signs showing the appropriate symbols. Inbound routes usually begin at the entrance to a taxiway from a runway. Mark inbound traffic routes at the beginning with appropriate destination areas on the airfield as required. Typical examples are “APRON”, “FUEL”, “MIL”, and “CARGO”. with an arrow indicating the route. This is a general guide and may be varied to meet local conditions, ground traffic, and variations in airport layout.

9.5.3. It is recommended that all mandatory taxiway guidance and information signs, and location signs be of the same size for a runway and associated taxiway complex. FAA Size 3 signs are recommended for facilities that have Category I operational capability, and for other higher volume airfields. An exception can be made at a particular location where a sign must be positioned closer to a runway or taxiway allowed for a Size 3 sign. In this case a smaller sign may be installed within its allowable distance from the surface.

9.5.4. Examples of sign layouts are shown in figures 9.4 and 9.5. Example for positioning a TACAN checkpoint sign is shown in figure 9.6.

9.6. Runway Distance Marker:

9.6.1. Purpose. Runway Distance Markers (RDM) are used to provide distance remaining information to pilots during takeoff and landing operations. The RDM are located along both sides of the runway, and the white numeral on the black background indicates the runway distance remaining in increments of 1,000 feet (metric units are not used). A runway distance marker is shown in figure 9.7.

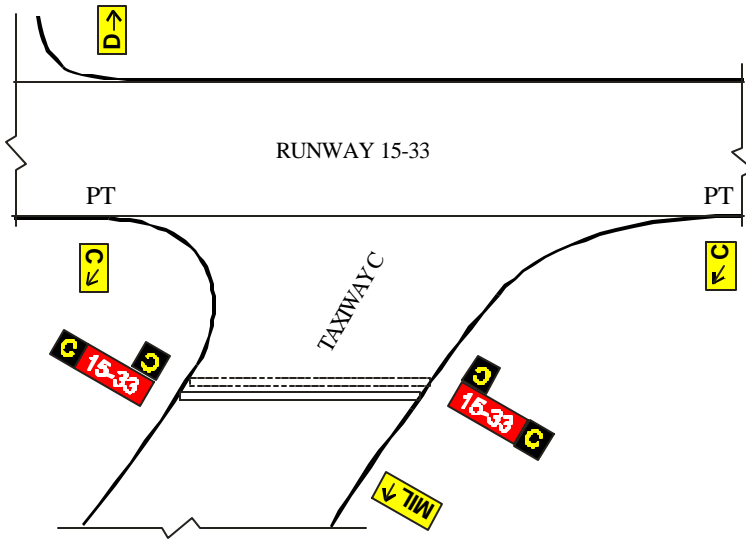
9.6.2. Installation. An RDM system is required for a runway on which jet aircraft operations are conducted. They are recommended for runways where only propeller-type aircraft operations are conducted.

9.6.2.1. The row of markers along each side of the runway is parallel to the runway centerline, and equal distance from the runway edge. FAA Size 4 RDM are positioned 15-22.5 meters (50-75 feet) from the runway edge. Use only FAA Size 4 RDMs.

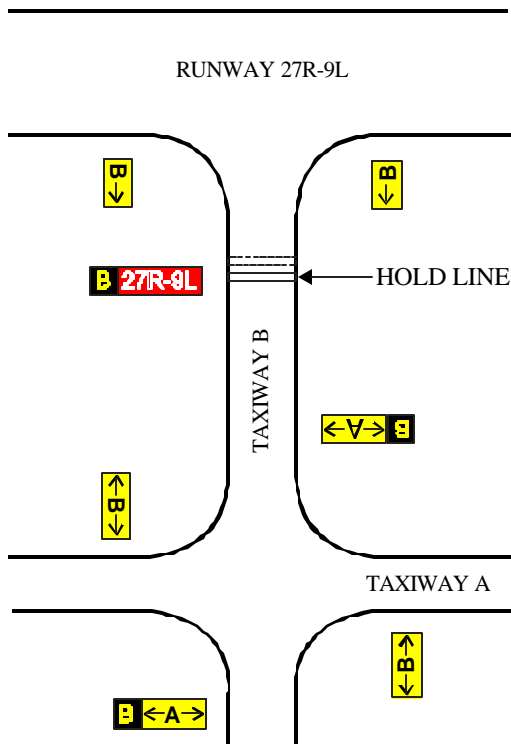
9.6.2.2. RDM are spaced at 300 meter (1,000 foot) intervals along the runway, excluding the threshold and runway end. Displaced threshold areas that are used for takeoffs and/or rollout are treated as part of the runway for purposes of locating the markers. Numerals are shown on both faces of the markers so the distance remaining can be seen in either direction of operations.

9.6.2.3. For runway lengths that are not an exact multiple of 300 meters (1,000 feet), one-half the excess distance is added to the distance of each marker for each runway end. For example, for a runway length of 6,500 feet, the excess distance is 500 feet and the location of the last marker on each runway end is 1,000 feet plus one-half of 500 feet, or 1,250 feet. A longitudinal tolerance of ± 15 meters (± 50 feet) is allowed if a marker cannot be installed at its standard location. A marker should be omitted if it cannot be installed within this tolerance. This standard procedure for siting RDM is illustrated by figure 9.8. Alternative methods can be found in FAA 150/5340-18, as allowed by the appropriate command.

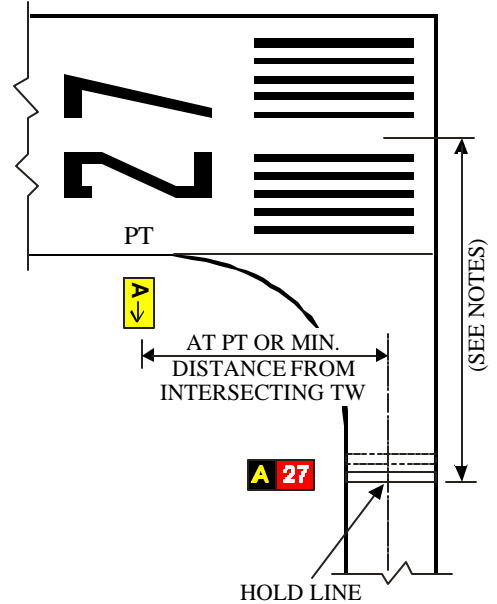
Figure 9.4. Examples of Signing Conventions.



A. SIGNS AT WIDE INTERSECTION WITH RW



B. TYPICAL SIGN APPLICATIONS



C. TYPICAL SIGN AT END OF RW

NOTES:

DISTANCE FROM EDGE OF RW OR TW TO INSIDE OF SIGN: 10.5-18M (35-60FT) FOR FAA SIZE 3 SIGN; 6-10.5M (20-35FT) FOR FAA SIZE 2 SIGN.

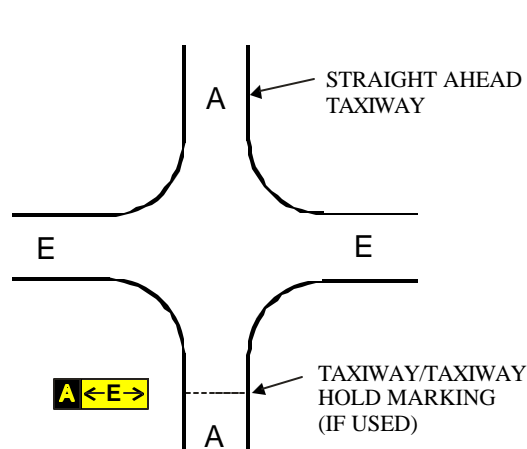
HOLD SIGNS COLLOCATED WITH HOLD MARKING. DISTANCE FROM RW CENTERLINE IS BASED ON APPROACH CATEGORY AND AIRCRAFT, AND WILL BE DEFINED BY MIL FOR EACH SITE.

SIGNS ARE LOCATED AT PT OR MINIMUM PERPENDICULAR DISTANCE FROM CENTERLINE OF CROSSING TW, WHICHEVER IS GREATER. MINIMUM DISTANCE PER FAA AC 150/5340-18 OR AS DETERMINED BY MIL..

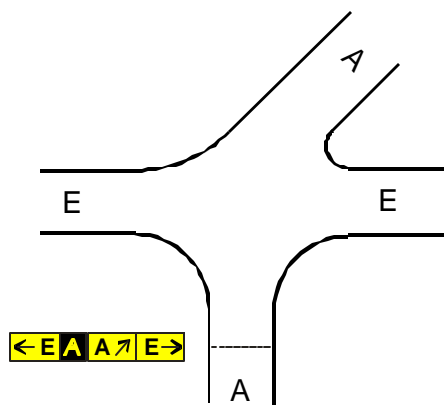
INSTALL SIGNS ON BOTH SIDES AT A LOCATION WHEN SURFACES ARE MORE THAN 45M (150FT) WIDE. SIGNS ON BOTH SIDES TO BE IDENTICAL, EXCEPT FOR HOLD SIGNS WITH LOCATION SIGNS (LOCATION SIGN IS TO OUTSIDE).

SEE FAA AC 150/5340-18 AND RELATED SUPPLEMENTS (SAMS) FOR MORE INFORMATION ON SIGN CONVENTIONS.

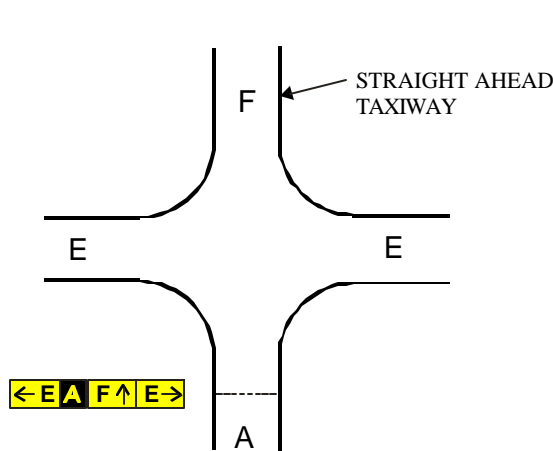
Figure 9.5. Signing Examples.



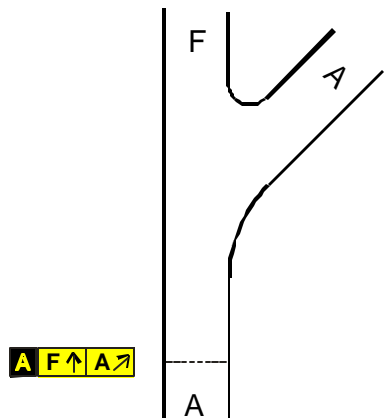
A STANDARD 4-WAY INTERSECTION.



B STRAIGHT AHEAD TAXIWAY HAS DIRECTION CHANGE GREATER THAN 25 DEGREES.

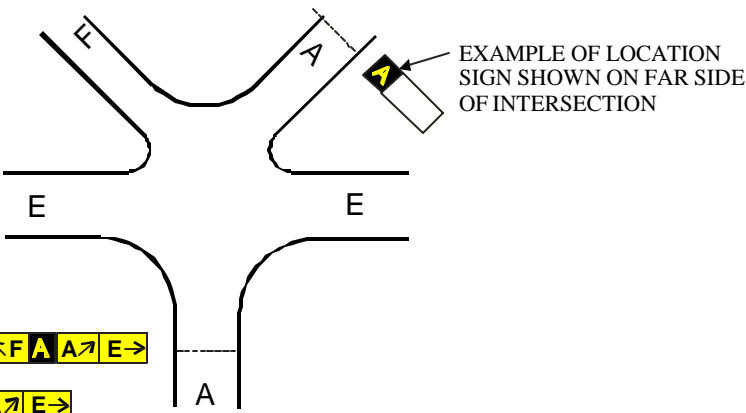


C. DESIGNATION OF STRAIGHT AHEAD TAXIWAY IS DIFFERENT.



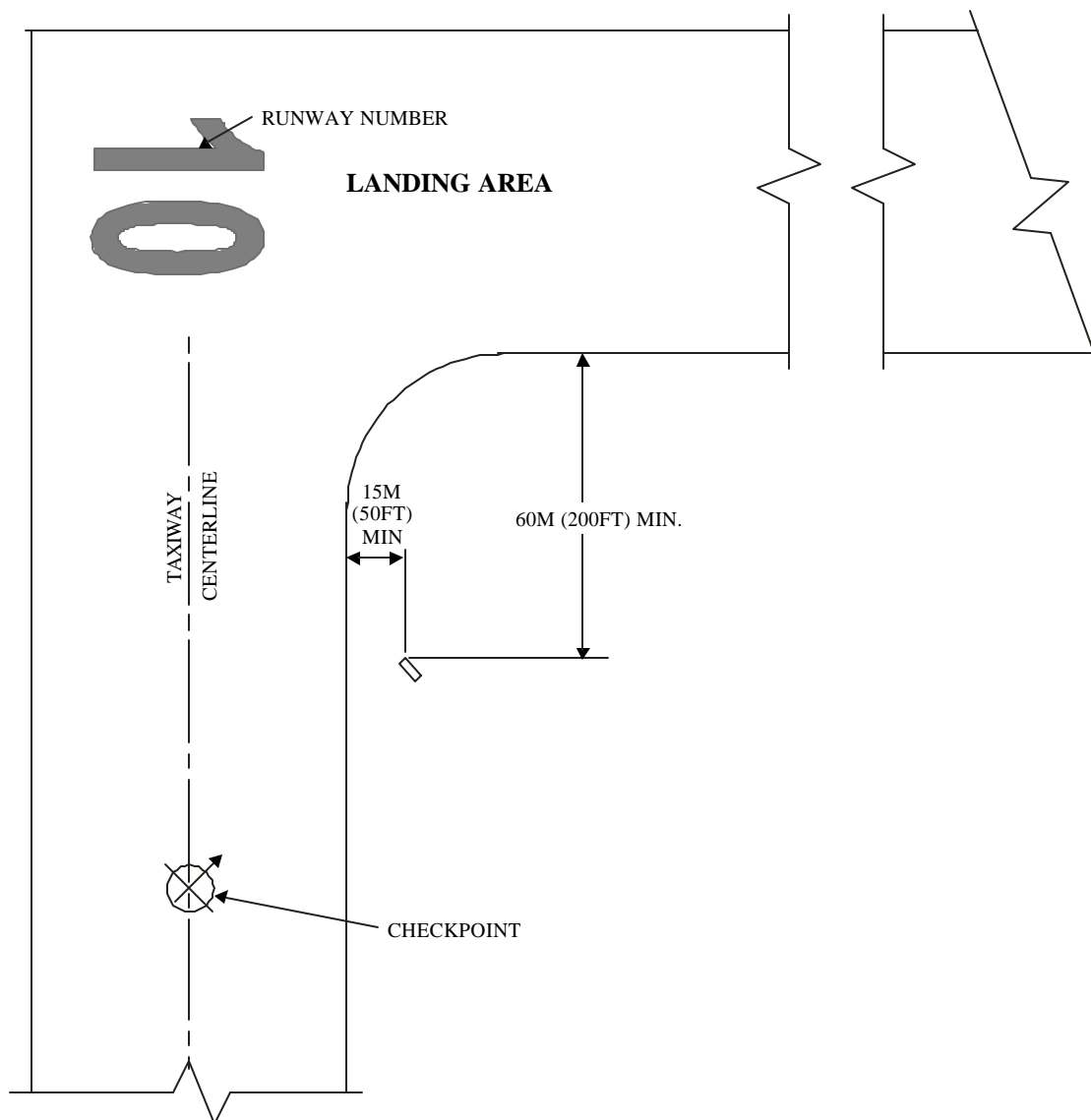
D. "Y" CONFIGURATION WITH TAXIWAY A CHANGING DIRECTION.

NOTE: ORIENTATION OF SIGNS ARE FROM LEFT TO RIGHT IN A CLOCKWISE MANNER. LEFT TURN SIGNS ARE ON THE LEFT OF THE LOCATION SIGN AND RIGHT TURN SIGNS ARE ON THE RIGHT OF THE LOCATION SIGN.



E. SIGNING AT INTERSECTION.

Figure 9.6. TACAN Sign Location.



9.6.2.4. Runway Distance Markers for military airfields are FAA Size 4, and are located 15-22.5 meters (50-75 feet) from runway edge. The distance indicated is to the inside edge of the marker. Markers are oriented perpendicular to and located equidistant from the runway centerline.

9.6.3. Characteristics. See Chapter 13, FAA 150/5340-18 Chapter 2, and FAA 150/5345-44 Appendix 1 for additional characteristic information.

9.6.3.1. Message. Signs are double face, internally lighted, with retro-reflective message faces that meet the color and reflectivity requirements of ASTM D 4956, Type I Sheeting. The spacing, stroke, and shape of legend characters, numerals, and symbols must be in accordance with FAA AC 150/5345-44, Appendices 1.

9.6.3.2. Dimensions. See FAA 150/5345-18 Chapter 1 for marker and legend height dimensions. FAA Size 4 sign has a legend height of 1020 millimeters (40 inches), legend panel height of 1220 millimeters (48 inches), and overall mounting height of 1370-1520 millimeters (54-60 inches). The marker should provide at least 30 centimeters (12 inches) clearance between the top of the sign and any part of the most critical aircraft expected to use the runway when the aircraft wheels are at the pavement edge.

9.6.3.3. Electrical. See paragraph 9.2.3.3.

9.6.3.4. Photometrics. The average sign luminance, as determined in accordance with FAA AC 150/5345-44, must be as follows for all intensity steps: white legend, 29 to 88 foot-lamberts.

9.6.3.5. If a training program for night VFR operations is to be conducted on an auxiliary airfield runway, retro-reflective tape may be used on markers (rather than internally illuminated numerals), provided the aircraft landing lights are adequate to illuminate the markers. Use of retro-reflective tape must be approved by the Major Command operations and flight safety officer.

9.6.4. Power and Control. RDM are typically connected to the runway edge lighting series circuit for the associated runway, or established as a separate circuit. Connection to runway edge lighting provides turning on and off with the runway lights. This can also be accomplished by interlock if RDM are on a separate circuit.

9.7. Arresting Gear Marker:

9.7.1. Purpose. Arresting Gear Markers (AGM) identify arresting gear pendant cables or barriers on the operational runway surface. The RDM are located adjacent to the location of arresting system cables on the runway. An AGM is shown in figure 9.7.

9.7.2. Installation. Arresting pendant cables must be identified by AGM on both sides of the runway. The AGM are located in line with the cable ± 3 meters (10 feet) and equidistant from the runway edge. AGM are similar to Size 4 RDM, and are positioned 15-22.5 meters (50-75 feet) from the runway edge. Where RDMs are installed, locate the AGMs in line with the RDM, except where the pendant cable is within 6 meters (20 feet) of an RDM. In this case relocate the RDM to be in line with the AGM and 1.5 meters (5 feet) outboard of the AGM. The distance indicated is to the inside edge of the marker. If the arresting gear is in the overrun, signs are not allowed but obstruction lights are required. See Chapter 6. This is a common requirement for the BAK-15. Markers are oriented perpendicular to the runway centerline. Typical installation of AGM is shown in figure 9.9.

9.7.3. Characteristics. See Chapter 13 for additional characteristic information.

9.7.3.1. Message. Messaging is similar to RDM (paragraph 9.6.3.1) except that the white numeral of the RDM is replaced with a yellow translucent circle approximately 1 meter (39 inches) in diameter facing both runway directions.

9.7.3.2. Dimensions. See paragraph 9.6.3.1 for legend dimensions. FAA Size 4 sign has a marker panel height of 1220 millimeters (48 inches) and overall mounting height of 1370–1520 millimeters (54-60 inches). As with RDM, the marker should provide at least 30 centimeters (12 inches) clearance between the top of the sign and any part of the most critical aircraft expected to use the runway when the aircraft wheels are at the pavement edge.

9.7.3.3. Electrical. See paragraph 9.2.3.3.

9.7.3.4. Photometrics. The average sign luminance, as determined in accordance with FAA AC 150/5345-44, must be as follows for all intensity steps: Yellow legend, 16 to 30 foot-lamberts.

9.7.4. Power and Control. See paragraph 9.6.4. The AGM should be powered from the same source and circuit as the RDM.

9.8. Other Signs:

9.8.1. Purpose. Other signs not listed above may be installed on the airfield to serve special needs. This may include signs that apply only to vehicle traffic and special purpose signs that are not included in current standards but that may meet specific needs.

9.8.2. Installation. Signs other than those listed in previous paragraphs must not conflict with current sign standards, and must not present confusing situations for ground traffic with respect to the sign's function and the standard signing on the airfield.

9.8.2.1. Signs intended for vehicles only, such as on vehicle service roads or lanes, typically follow the MUTCD. For example, standard highway stop signs may be installed on vehicle roadways at the intersection of each roadway with a runway or taxiway. A yield sign may be used in place of a stop sign at intersections with taxiways. Such signs should not be placed closer than a runway holding position for the same runway. Appropriate safe offset distances from FAA AC 150/5340-18, Table 3, must also be used where roadways cross taxiways.

9.8.2.2 Special purpose signs other than those listed above should be approved by the appropriate military authority based on a specific need at an airfield. Also, special circumstances may dictate that a standard sign is unsuitable for a particular location sign. Placement of non-standard signs should be as needed, but should not violate the requirements for standard signing listed above in terms of proximity to runways and taxiways. To the extent allowable and as appropriate for the application, non-standard signs should follow the guidelines contained in FAA AC 150/5340-18 and AC 150/5345-44.

9.8.2.3. In some cases standard signs may be painted on a pavement surface in order to enhance messaging. Painted signs on pavements should conform to AFI 32-1042.

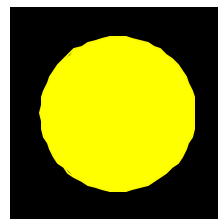
Figure 9.7. Typical RDM and AGM (Markers).



RUNWAY DISTANCE REMAINING
MARKER (RDM)

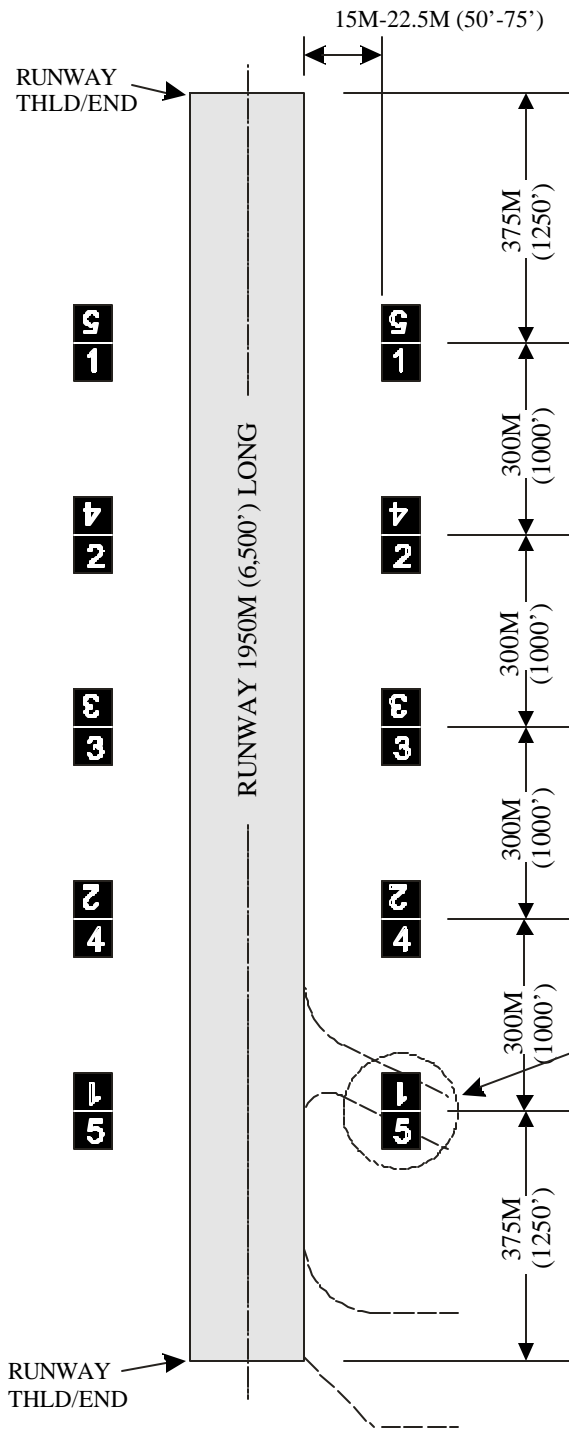
NOTE: RDM ARE FAA TYPE L-858B, WITH
WHITE LEGEND ON BLACK BACKGROUND,
MEETING FAA AC 150/5345-44, SIZE 4, STYLE 2 OR 3.

AGM HAVE CHARACTERISTICS OF RDM, BUT
WITH A YELLOW CIRCLE 1M (39") IN DIA. ON
BLACK BACKGROUND.



ARRESTING GEAR MARKER (AGM)

Figure 9.8. RDM Layout Configuration.



NOTES:

RDM ARE FAA TYPE L-858B, SIZE 4.

INSTALL RDM BOTH SIDES, EQUIDISTANT FROM THE RUNWAY CENTERLINE. LOCATE RDM IN STRAIGHT LINES PARALLEL TO THE RUNWAY CENTERLINE, WITHIN THE ALLOWABLE DISTANCE SHOWN, AS MEASURED FROM FULL STRENGTH PAVEMENT TO INSIDE EDGE OF RDM.

INSTALL AT 300M (1,000') INTERVALS, WITHIN TOLERANCE OF $\pm 15\text{M}$ (50') AT EACH LOCATION.

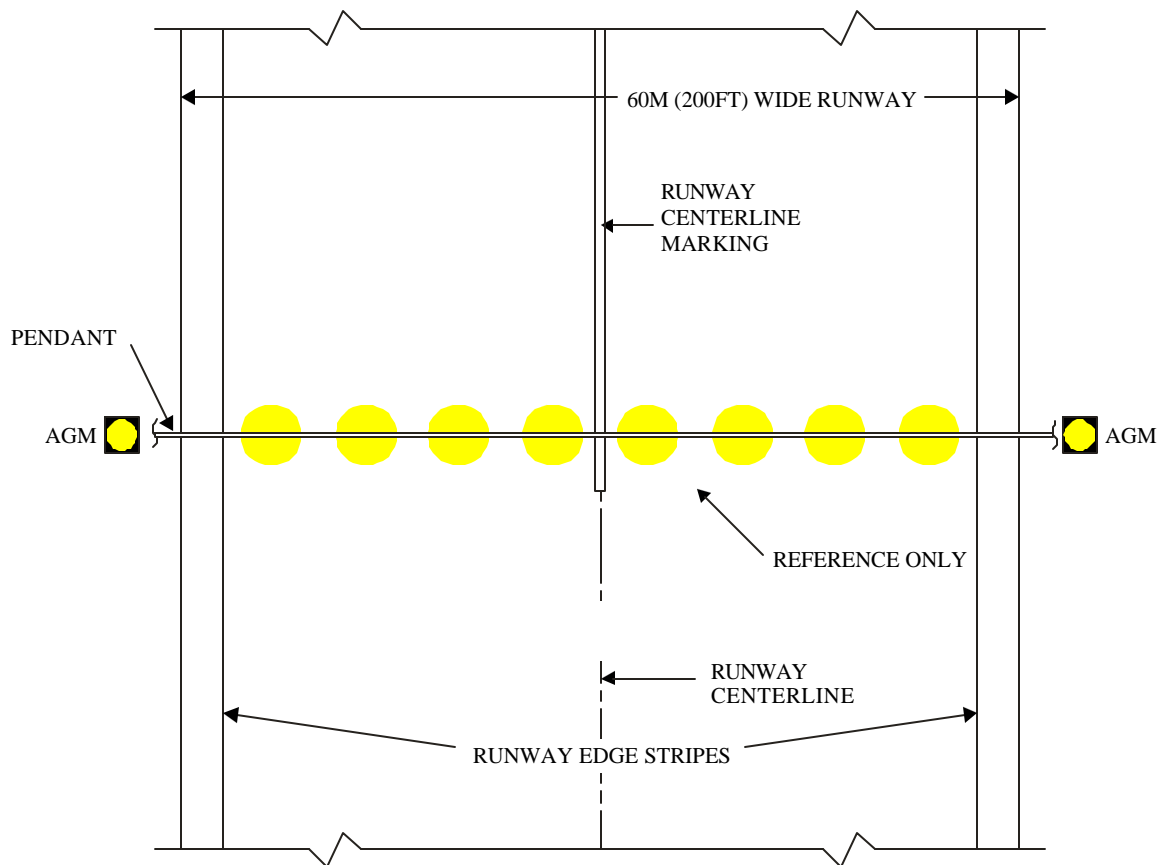
DO NOT INSTALL WITHIN 300M (1,000') OF RUNWAY ENDS (NO "ZERO" RDM).

EXAMPLE: 1950M (6,500') RUNWAY. IF RUNWAY LENGTH IS NOT DIVISIBLE IN 300M (1,000') INCREMENTS, ADD HALF THE EXCESS DISTANCE AT EACH END AS SHOWN (EXCESS DISTANCE IS 150M (500'), HENCE 75M (250') IS ADDED AT EACH END).

FAA AC 150/5340-18 PROVIDES GUIDANCE ON ALTERNATE CONFIGURATIONS (ONE SIDE ONLY, DIFFERENT TREATMENT OF EXCESS DISTANCE). THESE MAY ONLY BE USED WITH APPROVAL FROM THE AIRFIELD MANAGEMENT AND FLIGHT SAFETY OFFICES.

OMIT RDM, SUCH AS AT AN INTERSECTION, IF IT CAN NOT BE INSTALLED AT ITS STANDARD LOCATION EVEN AFTER ADJUSTING FOR ALLOWABLE LONGITUDINAL TOLERANCE.

Figure 9.9. Arresting Gear Marker (AGM) Configuration.



NOTES:

INSTALL AGM IN LINE WITH RDM.

IF AN RDM IS WITHIN 6M (20FT) OF AN AGM, THEN MOVE THE RDM EVEN WITH THE AGM AND INSTALL IT 1.5M (5FT) OUTBOARD OF THE AGM.

9.8.3. Characteristics. Vehicle signs should follow the requirements of the MUTCD. These are normally unlit signs, although in some cases external lighting may be useful. Other special purpose signs will be as required by the need, but must not conflict with or cause confusion with standard airfield signing.

9.9. Compliance with International Standards:

9.9.1. ASCC. This standard meets the requirements of AIR STD 90/27, Part Three, except for the location of signs at intersections.

9.9.2. NATO. This standard meets the requirements of STANAG 3316 for taxiway signs, except for minimum size of signs and the location of some signs at intersections.

9.9.3. See FAA AC 150/5340-18 and AC 150/5345-44 and ICAO Annex 14 for more information.

Chapter 10

MISCELLANEOUS LIGHTED VISUAL AIDS

10.1. Airport Beacons:

10.1.1. Purpose. Airport beacons are high-intensity flashing lights which provide a visual signal to pilots to assist in locating and identifying the airfield or a hazardous obstruction at night, or in restricted visibility conditions. These beacons may be rotating or fixed, but must provide the signal through 360 degrees of azimuth. These requirements are to be used for new installations of airport beacons. Existing installations may continue to be used and maintained until the first airfield lighting upgrade project.

10.1.2. Beacon Types:

10.1.2.1. Airfield Rotating Beacon. Each lighted airfield, except where one rotating beacon serves more than one airfield in close proximity, must use a high-intensity military type beacon. This beacon must have a double-peaked white beam to denote a military airfield and a single-peaked green beam to indicate that the airfield has lighted facilities for operations at night or in restricted visibility. The two beams must be directed 180 degrees apart. The signal from the beacon must be visible through 360 degrees of azimuth by rotating at six revolutions per minute (RPM). The airfield rotating beacon must be operated during twilight and night hours and during daytime when Instrument Flight Rules (IFR) are in effect. Alternating white and green flashes identify a lighted civil airport, and white flashes identify an unlighted civil airport.

10.1.2.2. Identification or Code Beacon. For Air Force only, the identification beacon is used only at airfields where the airfield rotating beacon is located more than 1800 meters (6,000 feet) from the nearest runway or where the airfield rotating beacon serves more than one airfield. The identification beacon is a non-rotating flashing omni-directional light visible through 360 degrees. This beacon flashes a green coded signal at approximately 40 flashes per minute. The signal is an assigned code of characters to identify the particular airfield. The identification beacon must be operated whenever the associated airfield rotating beacon is operated.

10.1.3. Location Requirements. The standard location for the airfield rotating beacon or the identification beacon must be:

10.1.3.1. Visible through 360 degrees of azimuth if possible.

10.1.3.2. Not less than 300 meters (1,000 feet) from the centerline or centerline extended of the nearest runway.

10.1.3.3. Not in the line of sight from the control tower to the approach zone of any runway or to within 22 meters (75 feet) vertically over any runway.

10.1.3.4. Located 225 meters (750 feet) or more from the control tower. This is intended to prevent light reflection during foggy conditions which reduce visibility and interfere with light gun signals from the control tower cab.

10.1.3.5. Not more than 1,800 meters (6,000 feet) from the nearest point of usable landing area, except if surrounding terrain will restrict visibility of the beacon through an appreciable angle in some directions or the beacon will serve more than one airfield. If terrain restricts viewing the beacon or the beacon will serve more than one airfield, the distance of the beacon from the nearest runway may be increased to not more than two miles.

10.1.3.6. The base of the beacon must be not less than 6 meters (20 feet) higher than the elevation of the floor of the control tower cab. If the airfield rotating beacon is located more than 1,800 meters (6,000 feet) from the nearest point of usable landing area, an identification beacon must be installed and not more than 1,800 meters (6,000 feet) from the nearest point of usable landing area.

10.1.4. Photometric Requirements. The photometric requirements for the airfield rotating beacon and the identification beacon must be:

10.1.4.1. Colors. The color of the emitted light must be standard aviation colors in accordance with the latest FAA criteria.

10.1.4.2. Airfield Rotating Beacon. With the lenses and the color filters removed and the beacon stationary and operating at rated voltage, the intensity in white light of each beam must be not less than 1,200,000 candelas for a distribution not less than one degree horizontally and 4.5 degrees vertically.

10.1.4.3. Identification Beacon. With the beacon operating steadily (not flashing) at rated voltage, the intensity of the green light must be not less than 1,500 candelas for a distribution through 360 degrees horizontally and 2 degrees vertically. The areas of the beam where the support rods are located may be less than these required intensities.

10.1.5. Aiming. The vertical aiming of the beacons should be properly focused and aimed when manufactured, and leveling should be all that is required for aiming during installation. The axes of the beams vertically should be approximately five degrees above the horizontal for the rotating beacon. For the identification beacon, the center of the beam must be approximately three degrees above horizontal.

10.1.6. Equipment. The airfield rotating beacon and the identification beacon equipment must be as shown in paragraph 13.12. The identification beacon must be provided with a keyer to flash the assigned identification code. The identification beacon is for Air Force only.

10.1.7. Power Requirements. The electrical power requirement for the beacons is 120 volts. The source of power may be from the airfield lighting vault or from a local source that is continuously available. If the distance from the power source is long and the line voltage drop is large, transmission of power at a higher voltage and step-down to 120 volts at the site may be desirable. The step-down transformer should be rated at not less than 3 KVA for the rotating beacon or 2 KVA for the identification beacon. Emergency power is not required for the airport beacons, but should be used if it is available.

10.1.8. Control Requirements. The controls for the airport beacons are only those required to energize and switch off the beacon and its drive motor or keyer. Preferably, these beacons should be controlled remotely from the lighting control panel in the control tower or the airfield lighting vault. Control may be furnished by an automatic photoelectric switch or a clock-driven timer.

10.1.9. Monitoring Requirements. There is no requirement for monitoring.

10.1.10. Compliance with International Military Standards. There are no International Military Standards for airport beacons.

10.2. Wind Indicators (Cones):

10.2.1. Purpose. Wind cones are installed near landing surfaces to provide a clear indication of the direction of the surface wind and a general indication of wind speed. Wind cones are lighted for night operation. The Air Force base/wing commander sets wind cone requirements with approval from the Major Command. For Army facilities the aviation community determines the required size of the wind cone.

10.2.2. Siting Requirements. Locate wind cones not less than 120 meters (400 feet) from the runway centerline and in a location free from the effects of air disturbances caused by nearby objects. If a wind cone is more than 8.3 meters (27 feet) above ground elevation a waiver to UFC 3-260-01 is required.

10.2.3. Wind Cone Configuration:

10.2.3.1. The wind cones must be in the form of a truncated cone made of fabric. They must have a length of not less than 2.4 meters (8 feet) and a diameter at the larger end of not less than 0.45 meters (18 inches). They must be constructed so it gives a clear indication of the direction of the surface wind and a general indication of the wind speed. Wind cones must extend fully in a fifteen knot wind.

10.2.3.2. The color(s) must be selected with consideration given to the background and to make the indicator clearly visible and understandable from a height of at least 300 meters (1,000 feet). Where practicable, use a single color, preferably white or orange. When a combination of two colors is required to provide conspicuity, the preferred colors are orange and white, red and white, or black and white. The colors must be arranged in 5 alternate bands, the first and last band being the darker.

10.2.4. Lighting Requirements. Illuminate the wind cone with floodlights which are arranged to provide a minimum illumination level of 2 footcandles (20 lux) at any point on the horizontal plane described by a complete rotation of the upper surface of a fully extended cone. The lights must be shielded to prevent light emission above the horizontal. Equip the wind cone support with an obstruction light.

10.2.5. Power Requirements. Provide a main power source only. If powered from the associated runway edge lights, they will have the provision so the cone floodlight brightness does not vary more than 20 percent with the available light, meeting the requirements of paragraph 10.2.4, at the lowest setting of the runway edge lights.

10.2.6. Control Requirements. On and off control is the only requirement and may be accomplished via the runway edge light circuit if used.

10.2.7. Monitoring Requirements. There are no requirements for monitoring wind cones.

10.2.8. Equipment. The wind indicators must be as shown in paragraph 13.12.3.

10.2.9. Compliance with International Standards. There are no ASCC or NATO standards for wind indicators.

10.2.10. See FAA AC 150/5345-27, *Specification for Wind Cone Assemblies*, for additional information.

10.3. Runway and Taxiway Retro-reflective Markers:

10.3.1. Purpose. Reflectors and retro-reflective markers may be used to supplement existing runway and taxiway lighting, or for temporary installations. However, a waiver must be granted by the Major Command for their use.

10.3.2. Characteristics. The retro-reflective materials used are designed to reflect light approaching at an oblique angle, back toward the light source.

10.3.3. Equipment. For additional guidance on the types and styles of the markers refer to FAA AC 150/5345-39 and AC 150/5340-24.

10.4. Other Auxiliary Lights:

10.4.1. Special arrangements of lights, such as apron or parking area floodlights and protective and security lighting, may be required at an installation. These lights will not be connected to the airfield lighting circuits. Supply and/or control voltages for these lights will be obtained from appropriate supply and control panels located at suitable operating points. Fixed area lighting facilities, such as floodlights for remote aircraft parking aprons and dispersed hardstands, will not be provided unless specifically authorized or directed. However, portions of parking aprons and dispersed hardstands specifically designated for technical training or major maintenance activities will be provided with electrical outlets, for use with portable lighting equipment supplied from the local distribution system. Hangar access aprons (hangar entrances) will not be considered in the above category and may be lighted by floodlights installed around the apron or mounted on the hangar. Where lights mounted on the hangar are not sufficient to light the access apron, or supplemental lighting is required for maintenance operations, outlets will be provided for use by portable lighting equipment and will be integrated with the power outlets. Floodlights and outlets provided for these areas may be considered as part of the hangar construction.

10.4.2. Floodlights. Ground mounted floodlights normally will be of the portable type. However, where deemed appropriate for a particular installation, adjustable fixed type floodlights may be installed. Floodlights at ground level should be of a type developed primarily for the purpose of confining the light below the horizontal without glare to the pilot or ground personnel. The floodlight will have a lens providing a horizontal spread of approximately 180 degrees and will be designed to give an even illumination of the horizontally lighted surfaces. Floodlights will be mounted at low elevations, preferably not more than 1 meter (3 feet) above the surface of the apron or servicing area. Floodlights will be rugged construction, dust-tight and weatherproof, suitable for outdoor installation on pipe stands, and will house a 200-watt minimum medium prefocus lamp. Floodlights for mounting on hangars will be of the general purpose type.

10.4.2.1. Fixed Floodlights Glare Control. Direct lamp light from the floodlights will be avoided in the direction of a control tower and landing aircraft. Aiming of the floodlights should be, as far as practicable, in the directions away from a control tower or landing aircraft. Direct light above the horizontal plane through a floodlight should be restricted to the minimum. To minimize direct and indirect glare, the mounting height of the floodlights should be at least two times the maximum aircraft eye height of pilots of aircraft regularly using the airfield. Also, the location and height of the masts should be such that inconvenience to ground personnel due to glare is kept to a minimum. In order to meet these requirements the floodlight light distribution may have to be restricted by use of screens.

10.4.2.2. Fixed Floodlights Design Considerations. Floodlight masts must meet relevant obstacle clearance requirements. Locate and aim the floodlights to minimize shadows. Horizontal illuminance should have a uniformity ratio (average to minimum) of no more than 4:1.

10.4.3. Protective Lighting. Where protective security lighting is required for the boundary of an area, the type of floodlight used will be of the wide-angle type, equipped with a Fresnel heat resisting clear glass that will provide a horizontal beam spread of 180 degrees and a vertical spread not greater than 30 degrees. These floodlights may be suitable for operation on either multiple or series circuits, whichever is most appropriate for the particular installation. Each floodlight should be not less than 200 watts or 4,000 lumens, with rugged, dust-tight and weatherproof construction. The mounting brackets will be adjustable to any position; the lamp focusing mechanism should be adjustable from the exterior of the fixture. Where areas inside the boundary, such as aprons and service areas, are floodlighted, floodlights mounted on poles or hangars should be of the general purpose type. When pole mounted, the height of the poles should ensure that, with proper adjustment of the floodlights, no glare or blinding light will affect aircraft operating in the traffic pattern or on the runways or taxiways. Poles should be located so as not to interfere with the line of sight from the control tower to the aircraft.

10.4.4. Lighting Intensities. The various areas of the airfield, heliport, or helipad requiring normal and/or protective floodlighting will be lighted to meet the following minimum intensities in footcandles, in the horizontal plane.

10.4.4.1. Apron Area Floodlighting:

Parking Area	0.50
Loading Area	2.00
Other Apron Areas	1.00
Maintenance	5.00*

* **NOTE:** Outlets for power and lighting should be installed at this area to supplement the lighting intensity at the work area and to focus light on the part of the aircraft being served.

10.4.4.2. Protective Lighting:

Boundary	0.20
Entrances	
Active, pedestrian and/or conveyance	5.00
Inactive, normally locked, infrequently used	1.00
Building surroundings	1.00
Apron	1.00

10.4.5. Power Outlets. Where installed, Army power outlets will be located in accordance with the spacing criteria of TM 5-803-4, *Planning of Army Aviation Facilities*. The outlets, when located off the paved areas, will be on pipe stands. Pipe stands will be located approximately 5 feet off the edge of the pavement and have a minimum practical projection above adjacent paving. Where outlets may interfere with traffic movement, they should be installed in cast iron boxes with hinged top, mounted in concrete bases. The top of the base should be flush with the finished grade surrounding the base. All outlets installations should be of weatherproof construction and sized for the loads to be served.

10.4.6. Additional Guidance. Additional information on auxiliary lighting can be found in joint services technical manuals:

10.4.6.1. Army/Navy/Air Force TM 5-684/NAVFAC MO 200/AFJMAN 32-1082, *Facilities Engineering Electrical Exterior Facilities*.

10.4.6.2. ARMY UFC 3-260-01 & TM5-811-1, *Electrical Power Supply and Distribution*, and Air Force AFJMAN 32-1080, *Electrical Power Supply and Distribution*.

Chapter 11

PORTABLE EMERGENCY LIGHTING

11.1. General Requirements. In times of emergency, when standard airfield lighting is not available and aircraft operations must be performed at night, it may be necessary to resort to the use of portable lighting devices to support the operations. The lighting design standards contained in this section may be suitable for use in VFR night operations but do not qualify the airfield for instrument operations of any kind. The standards in this section do not apply to requirements for forward tactical airfields or landing zones. See AFI 13-217, *Assault Zone Procedures*, for guidance on those requirements. Care should be taken when installing portable lights that they are secured sufficiently to prevent movement as a result of jet blast or other forces. When application of the criteria in this section would result in a light location in an active paved area, the light must be omitted or relocated as circumstances dictate. Information on the Emergency Airfield Lighting Systems (EALS) Light Set, Marker, Emergency Landing, manufactured by Multi-Electric, NSN 6230-01-291-7297, 88119653, TO 35F5-3-17-1 A/E82U-2 is available from the item manager, WR-ALC/LESC, DSN 468-7603, (478) 926-7603, or at Eglin AFB: DSN 872-4686. Multi Electric telephone number is: (773)722-1900; Fax (773)722-5694, and their address is: 4223 West Lake Street, Chicago, IL 60624-1787.

11.2. Runway Lighting:

11.2.1. Runway Edge Lighting. Portable edge light configurations generally follow the standard configuration except that the spacing may be a maximum of 90 meters (300 feet) and the offset may be a maximum of 3 meters (10 feet) from the runway edge. The runway edge lights must be white.

11.2.2. Runway End and Threshold Lighting. The number of lights required for runway end and threshold lights is reduced to 10. At each end of the runway they must be placed in two groups of 5 with the outermost lights in each group in line with the line of the runway lights spaced at 3 meters (10 feet) intervals toward the center. The line of threshold and runway end lights may be offset no more than 1.5 meters (5 feet) from the end of the runway. The lights must be red toward the runway and green toward the approach.

11.3. Taxiway Edge Lighting. The techniques for designing an emergency taxiway edge lighting system are generally the same as for a standard system except that the spacing is increased as follows:

11.3.1. Straight Sections: The spacing must not exceed 66 meters (220 feet).

11.3.2. Curved Sections: The spacing must not exceed 30 meters (100 feet).

11.4. Helipad Lighting. Emergency helipad lighting must follow the standard configurations for perimeter, landing direction, and approach direction lighting except the adherence to light plane criteria is not required.

11.5. Fixtures. Fixtures may be omni-directional, bi-directional or uni-directional. Where uni-directional fixtures are employed, they must be aimed in the direction of the planned operation. If the operational direction changes they must be installed for the new direction. Uni-directional fixtures generally have better light output for the energy being consumed than the other types. Omni-directional fixtures meeting MIL-L-19661, *Light, Marker, Portable, Emergency, Battery Operated*, Light, Marker, Portable, Emergency Airfield, Battery Operated, Type I may be used with filters as appropriate for the application. Uni-directional and bi-directional fixtures meeting , may also be used. Other portable fixtures that are suitable for outdoor use, meet the duty cycle requirements and meet or exceed the light output of the specified fixtures may be considered.

11.6. Controls. The specified lights have individual on/off controls and are not capable of control from a central point. They may have been provided with a flashing mode which must not be used during periods when aircraft operations are being conducted.

11.7. Compliance With International Military Standards. These standards comply with NATO STANAG 3534, *Airfield Portable Lighting*, and ASCC AIR STD 90/20, *Airfield Portable Lighting Systems*, except for light output of the fixtures.

11.8. Contingency Airfield Night Lighting System (CANLS). The current authorized permanent contingency lighting pattern for Air Mobility Command (AMC) aircrews is the Airfield Visual Aids Pattern, (AVAP-1), Figure 3.2, in AFI 13-217.

PART 2 - SYSTEM INFORMATION

Chapter 12

DESIGN AND INSTALLATION GUIDELINES

12.1. Special Air Force Requirements:

12.1.1. General Guidelines. When design options exist and operational requirements do not dictate a clear choice between them, base the decision on the results of a life cycle cost analysis rather than the lowest first cost. All interior and exterior elements of the airfield lighting systems must meet the requirements of this document. Refer to UFC 3-535-02, *Design Drawings for Visual Air Navigation Facilities*, for detailed installation information.

12.1.2. Light Fixture Mounting. Wherever practical, mount the light fixtures on bases installed in a concrete envelope. The mounting bases support the light fixture and normally house the isolation transformer. For temporary construction the light fixtures may be stake mounted, and the transformers may be surface mounted.

12.1.3. Concrete Foundations. All foundations for lights, signs, towers, and other equipment must be flush with the grade and the surrounding area stabilized and compacted to prevent erosion and excessive rutting in the event an aircraft strays from the pavement.

12.1.4. Cable and Duct Installation. Wherever practical, install cables in approved underground duct. Cable must be suitable for underground installation, and installed either in concrete encased or direct buried duct. Use concrete encased duct under paved areas. When installation under existing pavement is required, the designer must select the best conduit for the application considering strength and corrosion resistance. For temporary construction, the cables may be direct buried. Make connections between the lighting cable, isolation transformers, and light fixtures with FAA L-823 connectors. Cables for taxiway centerline, runway centerline and touchdown zone lights may be installed in conduit or in saw kerfs cut in the pavement. While direct installation in saw kerfs is permitted, ensure the cable is constrained below the pavement surface and protected from damage resulting from differential expansion or movement. Recommendations for the designer to consider regarding cable and duct installation are contained in table 12.1.

12.1.5. Equipment Grounding System. Install #6 copper AWG green-jacketed wires identified as an equipment ground, in ducts with primary circuit and connect all light bases. Note, if used for approach lights without a light base, connect ground to each light fixture and to the vault lighting system.

12.1.5.1. Ground Criteria. The ground wire serves as a safety ground, protecting against high voltages that could be brought to the light base. As an alternative, each aviation light base will be grounded with a ground rod. System safety ground wires are to be bonded only at the vault, manholes and handholes, light bases and cans. See the following paragraphs for providing a counterpoise system for lightning protection.

12.1.6. Counterpoise Lightning Protection System. Provide a continuous counterpoise of number 4 (minimum) AWG bare, stranded copper wire over the entire length of all primary circuits supplying airfield lighting: outside pavements, with a minimum 2.4 meter (8 foot) ground rod installed at least every 300 meters (1,000 feet). Do not connect counterpoise system to the light bases.

12.1.6.1. Counterpoise Criteria. Along runway/taxiway or apron shoulders, install the counterpoise halfway between the pavement and at approximately half the depth of the duct (or cable, if direct buried) if at all possible. If this is not practical, install counterpoise 10-15 centimeters (4-6 inches) above the duct or direct-buried cable. Route the counterpoise around each light base or unit, at a distance of about 0.6 meters (2 feet) from the unit; do not connect to the unit. For duct not along a shoulder or for duct bank, lay the counterpoise 10-15 centimeters (4-6 inches) above the uppermost layer of direct buried ducts, or on the top of the

concrete envelope of an encased duct bank. Provide only one counterpoise wire for cables for the same duct bank. Connect all counterpoise wires leading to a duct bank to the single counterpoise wire for the duct bank. Lay the counterpoise at least 0.3 meters (12 inches) from any light cans or in routing counterpoise around manholes or handholes. Do not connect the counterpoise to the lighting vault power grounding system. Use brazing or thermoweld for all connections. The counterpoise resistance to ground must not exceed 25 ohms at any point using the drop of potential method.

12.1.7. Frangibility and Accident-Avoidance Construction. In the areas around the runway, including the approach zone, all above-grade structures must be lightweight and of a frangible or low impact resistant construction using breakaway sections to minimize hazards to aircraft. Concrete foundation or mounting slabs must not extend above the finished grade of the surrounding surface.

12.1.7.1. ALSF Frangibility. A slight trade-off in frangibility can result in significant savings in energy. Older ALSF systems use 300 watt lamps in the outer 600 meters (2,000 feet) to satisfy the photometric requirements, which can actually be met with newer 200 watt lamps. However, the 200-watt lamps are rated at 6.6 amps rather than 20 amps and their use would require a change in isolation transformers. This would not be difficult in major renovations or new installations except that eight additional wires must be installed in low impact resistant and semi-frangible light supports. The Major Command may accept the slight loss of frangibility in order to achieve the energy savings.

12.1.8. Airfield Lighting Vault. Vaults house the regulator and control equipment, emergency generator and power transfer switch, and other electrical equipment needed for operation of the airfield lighting system. The vault may be a separate building or structure, or an enclosure within a larger structure, as appropriate. Vaults must be of concrete or masonry construction meeting all building codes for the type of structure. Vaults constructed in the past generally had a primary service of 4160/2400 volt, 3 phase, 60 hertz power. All existing vaults not meeting the above described location may be used, provided the existing structure is otherwise adequate to serve the overall purpose or can be modified economically to provide the desired facility. For new construction or major modernization, the following is recommended:

12.1.8.1. Vault Voltage. Use 480 volts as a primary voltage within the vault.

12.1.8.2. Vault Location. Locate vaults a minimum horizontal distance of 107 meters (350 feet) from the control tower to prevent radio interference with control equipment. The maximum horizontal distance between an airfield lighting vault and the control tower where nominal 120 volt control system is used (with L-841 relay panel and multi-conductor control cable) is 2,240 meters (7,350 feet). An existing vault not meeting required locations may be used, provided the existing structure is otherwise adequate to serve the overall purpose or can be modified economically to provide the desired facility.

12.1.8.3. Main Lighting Vault. The main airfield lighting vault should contain power distribution and control equipment for runway and taxiway lighting circuits and any other lighting circuits that can feasibly use this source. It also should provide adequate space for the maintenance of the systems. Auxiliary vaults may be required for other airfield systems depending on the airfield configuration. Locate the vaults above grade in locations that are the most suitable as supply points. For Army airfields, size the vault for the required equipment and work space and space allowances indicated in UFC 3-260-01. Provide a two-hour fire rated wall to isolate the engine generator room from the regulator room.

12.1.8.4. Approach Lighting Vault. The approach lighting vault houses power distribution and control equipment primarily for the approach lighting and sequenced flashers, but other lighting systems nearby may also use this vault as a power source. Locate the vault adjacent to the approach zone at a sufficient distance to satisfy obstruction criteria.

12.1.8.5. Floor Mounted Equipment. Securely bolt all floor-mounted equipment to the floor to prevent movement during seismic disturbances.

Table 12.1. Considerations for Cable and Duct Installation.

1. Install cables in the same location and running in the same general direction in the same trench or duct bank. Whenever possible, route cables in straight duct segments between manholes and handholes, or between light bases.

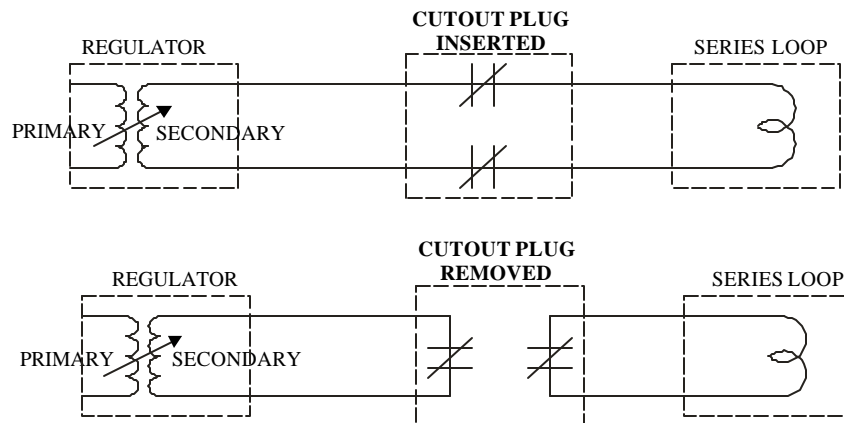
When practical, route cables and duct rectilinear (parallel and at right angle) to runways, taxiways, and other surfaces.
2. Separate low voltage ($\leq 600\text{V}$) from higher voltage cables ($> 600\text{V} - 5,000\text{V}$). Separate all power cables from control, telephone, and coaxial type cables.
 - 600V and 5,000V power cables should be placed in separate duct, or separated minimum 10cm (4") if direct buried in trench.
 - Power cables of more than 5,000V must be separated from all other cables by minimum 25cm (12").
 - All power cables should be in separate duct bank from all control, telephone, coaxial type cables, or separated minimum 15cm (6") if either is direct buried.
3. If cables are placed at more than one level, the minimum vertical separation should be same as the minimum horizontal separation. Do not directly overlap cables, in order to avoid damage during compaction.
4. Do not direct-bury cables under paved areas, roadways, railroad tracks or ditches.
5. Where rock excavation is encountered, install cable in duct. Remove rock to depth of at least 8cm (3") below required depth of duct, and use adequate bedding material to provide uniform support along entire length.
6. Trenches for single-duct lines that are not encased with concrete should not be less than 15cm (6") nor more than 30cm (12") wide, and the trench for 2 or more ducts should be proportionately wider.
7. For duct banks, use interlocking duct spacers at not more than 1.5M (5') to ensure uniform spacing between ducts and to hold duct in place when concrete encasing. Stagger joints in adjacent duct at least 0.6M (2').
8. Provide burial below frost line to prevent damage from frost heave if local experience has indicated problems.
9. Concrete encased duct is recommended where the area is inhabited by digging rodents or animals. This is to provide physical protection.
10. Slope duct lines where practical for drainage towards manholes/handholes, or duct ends.
11. Provide ground bushings where rigid conduits enter or leave a manhole.
12. Provide whenever possible at least 25% spare duct in a duct bank over and above the planned installation and any known future expansion.
13. Where conduit is bound in pavement or other structural feature, provide conduit expansion joints when crossing pavement expansion joints. Consider conduit expansion joints also where local experience has indicated expansion problems.

[See also typical installation details,UFC 3-535-02]

12.1.8.6. Space for Constant Current Regulators. Constant current regulators require adequate space for maintenance access and high voltage safety. The following minimum spacing is recommended: 1 meter (3 feet) from back wall to regulator and between regulators; 1.2 meters (4 feet) in front of regulator for access.

12.1.8.7. Vault Wiring Safety. S-1 cutouts provide safety by preventing inadvertent live wires during maintenance on field circuits. These are recommended at the output to field circuits for constant current regulators. Install S-1 cutout in NEMA 1 enclosures. A circuit diagram for an S-1 cutout is shown in figure 12.1.

Figure 12.1. S-1 Cutout Circuit Diagram.



12.1.8.8. New Installations. For new installations, install cables in conduit or enclosed wireways. The standard L-824 airfield lighting primary series circuit cable does not comply with NEC for installation in open trays. High voltage conductors (exceeding 600V) should be run in rigid steel galvanized conduit or intermediate metal conduit. Low voltage feeders and control wires may be run in rigid steel galvanized conduit or intermediate metal conduit when run under the floor slab; in rigid steel galvanized conduit, intermediate metal conduit, or electrical metal tubing (EMT) when run on the walls or ceiling; and in cable trays supported from the ceiling or walls when there are many cables and the possibility of future expansion. Do not install conduit in concrete slabs on grade. Bring primary series cable from regulators and various other feeders out of the vault in coated rigid steel galvanized conduit minimum 0.6 meters (2 feet) below grade.

12.1.8.9. Installation Compliance. Comply with the requirements of the NEC (NFPA 70) for the installation of power distribution equipment and control equipment in lighting vaults. See AFMAN 32-1181, *Design Standards for Interior Electrical Systems*, for lightning and surge protection design requirements. It is recommended to review the checklist for vault contained in Chapter 14.

12.1.8.10. Short Circuit Analysis. Perform a short circuit analysis as part of design (to enhance reliability and safety). Short circuit analysis should comply with: NEC Section 110-9, Section 110-10 and Section 110-12; and FAA Order 6950.27. Include in the analysis critical points such as:

- 12.1.8.10.1. Service entrance.
- 12.1.8.10.2. Switchboards and panelboards.
- 12.1.8.10.3. Transformer's primary and secondary.
- 12.1.8.10.4. Transfer switches.
- 12.1.8.10.5. Load centers.
- 12.1.8.10.6. Fusible disconnects.

12.1.9. Emergency Power. Provide an emergency generator or other independent power source at each vault which services systems requiring standby power for continuous operation if the principal power source fails:

12.1.9.1. Engine Generator (E/G). Where engine generators are installed, provide a separate room or shelter with independent ventilation. Make provision for engine exhaust to the exterior of the shelter. Mufflers may be installed inside or outside the building. If installed inside, they must be insulated. Engine cooling may be provided by externally-mounted radiators or by use of a radiator duct to an external exhaust louver. Make provisions for mounting and cooling resistive load banks for diesel engine testing if the station load is inadequate or cannot be made available for engine testing. Provide fuel storage capacity for 72 hours of uninterrupted operation of the standby power system. Also provide automatic starting and switching capable of supplying the rated load within 15 seconds of a power failure except where Category II instrument operations are conducted. During Category II instrument operations, a one-second power transfer is required. This is normally done by providing a remote start capability which permits operation of the lighting systems on the engine generator during Category II weather conditions. Standby power availability is then subject only to switching time. The actual procedure used must be locally coordinated. See FAA Advisory Circular 150/5340-17, *Standby Power for Non-FAA Airport Lighting Systems*, for additional information. Provide an automatic battery charger for the starting batteries. Isolate the E/G foundation slab to reduce vibration and noise transmission to other parts of the vault. Comply with the requirements of the NEC, OSHA and local jurisdictions for emergency power.

12.1.10. Independent Power Sources. An alternate independent power source qualifies as emergency standby power only if it is generated by a separate power generating station and routed over separate power lines. In most cases in the past, careful investigation revealed that seemingly independent sources were so interconnected that failure of one could result in failure of the other. Exercise extreme care when determining the qualifications of alternate power sources before opting against an engine/generator for standby power.

12.1.11. Airfield Lighting Control. The control system for airfield lighting consists of control panels, relaying equipment, accessories, and circuits which energize, de-energize, select lamp brightness, and otherwise control various airfield lighting circuits based on operational requirements. Control of any one airfield lighting system is normally provided at two points only: the control tower, and the vault which powers the system. See figure 12.2 for a typical lighting vault block diagram. A transfer relay assembly is provided at the vault to transfer control from the remote location to the vault when necessary:

12.1.11.1. Control Voltages. Standard practice is to provide a 120 VAC control system using low burden pilot relays (pilot relay assemblies) to activate the power switches, contacts, and relays controlling the regulators and transformers supplying power to the airfield lighting circuits. The maximum horizontal distance from the control tower to the lighting vault is limited, for proper function of the pilot relay assemblies, to 2,240 meters (7,350 feet) when using 120 VAC control systems. Where the distance between the tower and the vault exceeds the maximum, consider using a 48 VDC control system as described in FAA AC 150/5340-24. Where both types of control system are installed, ensure the control power systems are isolated. (See figure 12.3.)

12.1.11.2. Control Circuitry. Design the control system to ensure the following:

12.1.11.2.1. Lighting on intersecting runways cannot be energized simultaneously.

12.1.11.2.2. All circuits supplying the lights for any one lighting system (for example, runway edge lighting) are energized simultaneously and operated at the same brightness step.

12.1.11.2.3. Runway centerline lights cannot be energized unless the runway edge lights are energized.

12.1.11.2.4. Touchdown zone lighting (TDZL) cannot be energized unless the runway centerline lights are energized.

Figure 12.2. Installation Plan, Power Equipment.

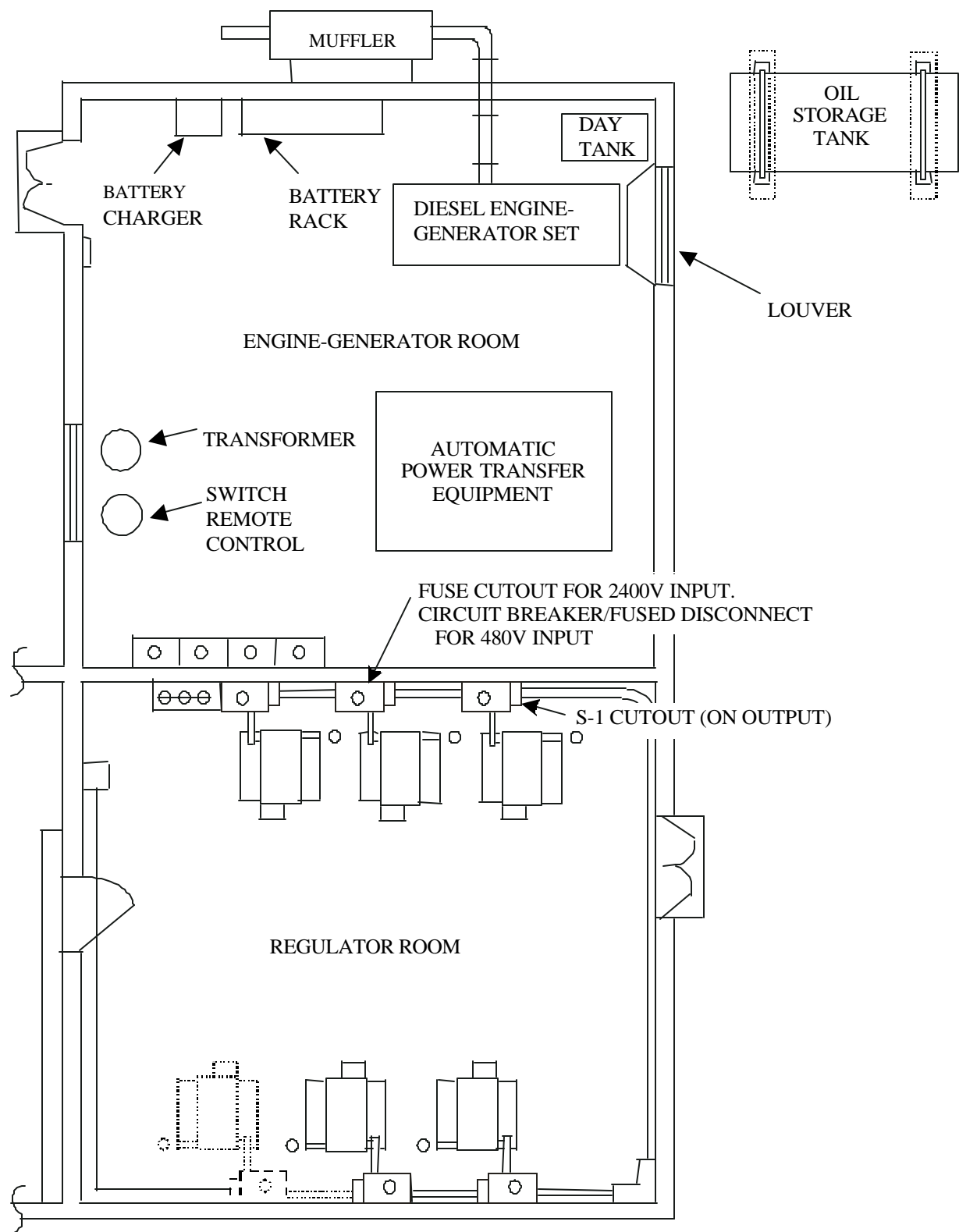
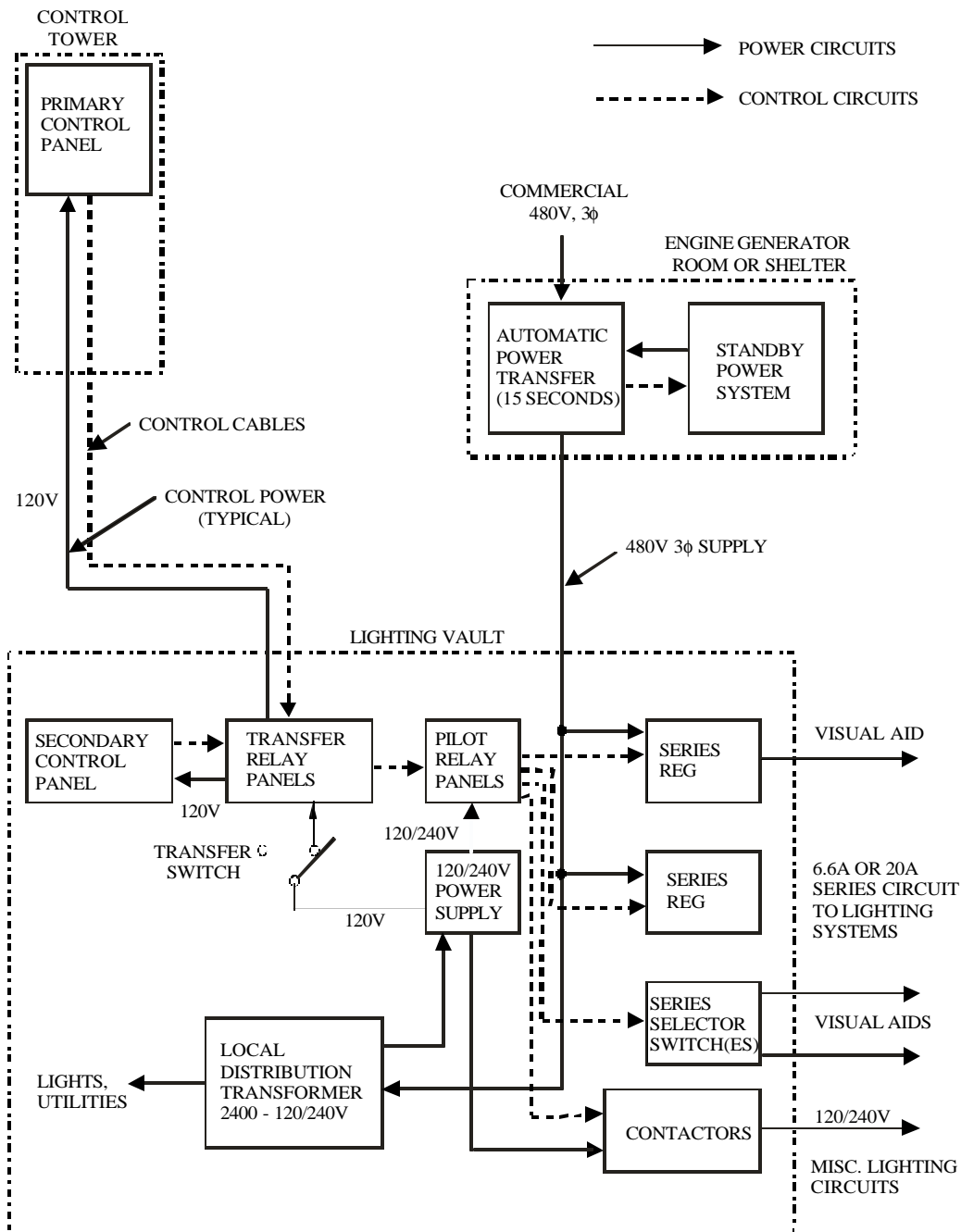


Figure 12.3. Power and Control System Block Diagram.



12.1.11.2.5. Certain systems associated with low-visibility operations (such as runway guard lights, hold-position lights, lead-in lights, land-and-hold-short lights), if installed, may also require linkage of control to runway lights. Recommend following guidance of applicable FAA documents, such as FAA AC 120/57, *Surface Movement Guidance and Control System (SMGCS)* and FAA AC 150/5345-46.

12.1.11.3. Control System Modernization. Major commands are encouraged to consider the use of multiplex control systems, where significant economies or operational improvements can be achieved. If an approved specification is not available, the use of such systems is subject to the requirements of paragraphs

1.8 or 1.9 of this document. Control systems using electromagnetic emissions also require the express approval of HQ AFCEA/CESM. Paragraph 13.16 provides guidance for computerized control systems. As examples, figure 12.4 shows a block diagram for a control system using programmable logic controllers (PLC), and figure 12.5 shows a block diagrams for a PC-based control system. Further discussion of computerized control systems is also provided in Chapter 15.

Figure 12.4. Computerized Control System using PLC Block Diagram.

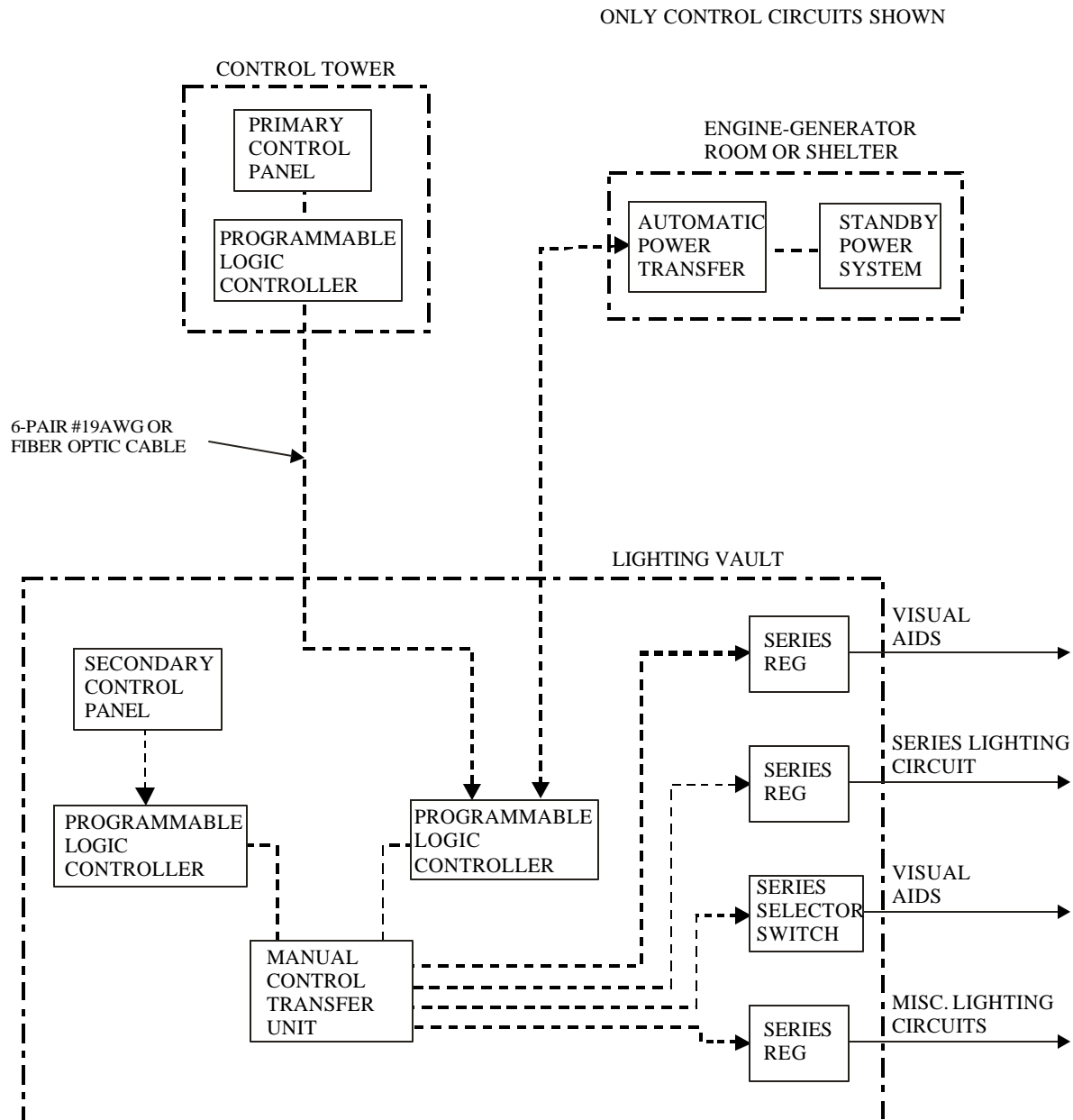
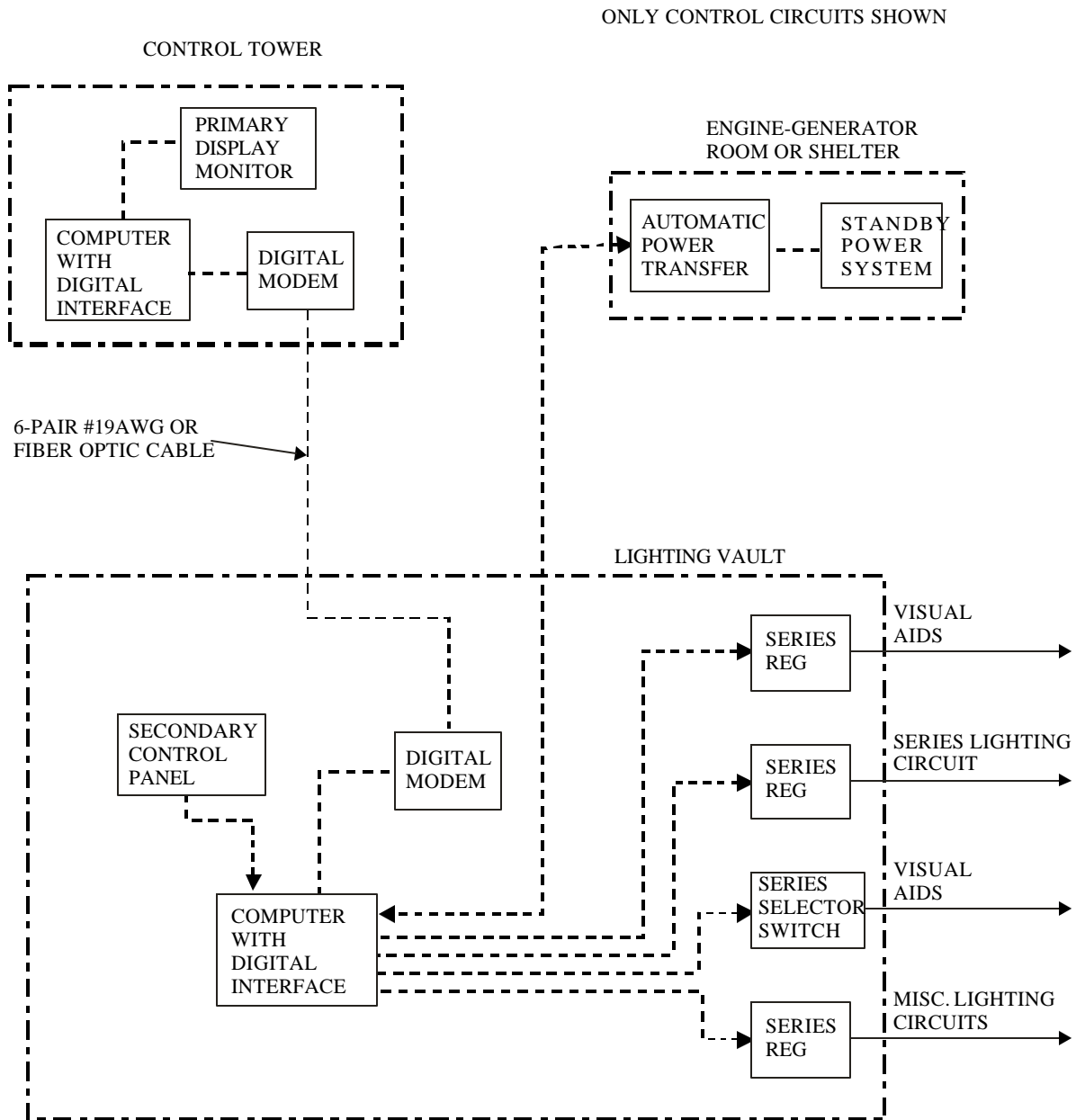


Figure 12.5. Computerized Control System using PC Block Diagram.



12.1.12. Light Colors. For colors of light, see the applicable FAA Advisory Circular and the Chromaticity (CIE) color coordinate diagram at figure 13.1.

12.1.13. Light Intensity:

12.1.13.1. The brightness steps for the levels of lamp intensity are shown in table 12.2.

Table 12.2. Intensity Requirement Levels for Various Circuits.

BRIGHTNESS STEP	AMPERAGE READING 20-AMPERE CIRCUIT	AMPERAGE READING 6.6-AMPERE CIRCUIT	APPROXIMATE PERCENT RATED INTENSITY
1	8.5	2.8	0.16
2	10.3	3.4	0.80
3	12.4	4.1	4.00
4	15.8	5.2	20.00
5	20.0	6.6	100.00

12.1.13.2. The brightness steps for three levels of lamp intensity are achieved by varying the current in the lighting circuit as follows:

Brightness Level	Service Systems Lamp Current (amps)	Percent Brightness
High	6.6	100
Medium	5.5	30
Low	4.8	10

12.1.14. Special Considerations for Series Circuits:

12.1.14.1. Selection of 6.6 or 20 Amperes Circuit. The determination of whether to use a 6.6 amperes or 20 amperes series circuit must be based on several factors relating to the characteristics of the circuit and the anticipated conditions under which the circuit will be operated. In general, if a circuit is not expected to operate at highest intensity more than 5% of the time, and if design calculations show that the voltage will not exceed 2400 volts when operated at the mid level (step 2 for 3-step circuits, step 3 for 5-step circuits), then a 6.6 ampere circuit is recommended. If a circuit is expected to operate at highest intensity more than 5% of the time, and if design calculations show that the line voltage will be more than 2400 volts at the mid-level, then consideration should be given to using a 20 amperes circuit, or alternatively using more than one 6.6 amperes circuit. Analysis should consider the economics over the expected life of the system, typically 20 years. A more detailed discussion of this can be found in Chapter 15. Recommend designing for multiple 6.6 ampere circuits instead of 20 ampere circuits.

12.1.14.2. REIL on Series Circuits. REIL (runway end identifier lights) are typically connected to the runway edge lighting series circuit via power adapter, or to a separate power source of 120/240 volts. If connected to a series circuit, it is necessary to consider the sizing of the regulator carefully to allow for the pulsing type of load. The impact on the constant current regulator may up to 10 times the power requirement indicated by the manufacturer. More information on this can be found in Chapter 15.

12.1.15. Floodlights. Apron parking areas are typically lighted to 0.5 footcandles. Apron loading areas are typically lighted to 2 footcandles vertical. Hangar areas are typically lighted to 1 footcandle. The functions of the apron floodlights are:

- 12.1.15.1. Assist the pilot in taxiing the aircraft into and out of the final parking position.
- 12.1.15.2. Provide lighting suitable for passengers to embark and debark; for personnel to load and unload cargo and refuel; and to perform other apron service functions.
- 12.1.15.3. Maintain airfield security.

12.2. Additional Guidance:

12.2.1. General. The FAA has published guide specifications for installation of airfield lighting systems. FAA guide specifications come in two forms: advisory circulars in the 5340 series, and FAA-C specifications. A listing of applicable publications is provided below. Where those guides are in conflict with the Air Force requirements listed above, the Air Force requirements take precedence. The FAA has an Advisory Check List AC 00-X.X that provides a list of documents, and how to order them. Contact the FAA at 1-800-FAA-SURE, (fax: 301-386-5394).

12.2.2. FAA Advisory Circulars (ACs). FAA advisory circulars may be obtained from the Department of Transportation. Subsequent Distribution Office, Ardmore East Business Center, 3341 Q 75th Avenue, Landover, Maryland, 20785. Request latest editions: (Fax: 301-386-5394).

12.2.2.1. AC 150/5340-4. *Installation Details for Runway Centerline Touchdown Zone Lighting Systems* describes standards for the design and installation of runway centerline and touchdown zone lighting systems.

12.2.2.2. AC 150/5340-17. *Standby Power for Non-FAA Airport Lighting Systems* describes standards for the design, installation, and maintenance of standby power for non-agency owned airport visual aids associated with the National Airspace System (NAS) and the national system of airports.

12.2.2.3. AC 150/5340-18. *Standards For Airport Sign Systems* describes the recommended standards for design and installation of a taxiway guidance sign system.

12.2.2.4. AC 150/5340-21. *Airport Miscellaneous Lighting Visual Aids* describes standards for the system design, installation, inspection, testing and maintenance of airport miscellaneous visual aids, i.e., airport beacons, beacon towers, wind cones, wind tees, and obstruction lights.

12.2.2.5. AC 150/5340-23. *Supplemental Wind Cones* describes criteria for the location and performance of supplemental wind cones.

12.2.2.6. AC 150/5340-24. *Runway and Taxiway Edge Lighting System* describes standards for the design, installation, and maintenance of runway and taxiway edge lighting.

12.3. Siting PAPI:

12.3.1. Considerations. Siting a PAPI requires consideration of the following: if there is or will be an ILS glide slope, the established glide path (aiming angle, typically 3 degrees), the threshold crossing height (TCH) for the selected aircraft height group, the runway gradient (longitudinal slope) from the threshold to the PAPI location, and other factors.

12.3.1.1. With an ILS glide slope, the PAPI is located the same distance from the runway threshold so that the elevation of the lens center of the light units intercepts the runway at the same location as the virtual source of the ILS glide slope, within a tolerance of ± 10 meters (± 30 feet), and is aimed at the same angle as the ILS glide slope. The virtual source is the Runway Point of Intercept (RPI), where the glide path intercepts the ground elevation along the runway centerline. PAPI location considers the light beam, where the elevation of the lens center of the PAPI light units should intercept the ground elevation along the runway centerline (within tolerance). For aircraft in height group 4 (table 3.3) for Army airfields only, the PAPI is sited at the RPI plus an additional 90 meters (300 feet), +15 meters –0 meters (+50 feet –0 feet), from threshold.

12.3.1.2. If there is no ILS glide slope, the PAPI is sited as shown in figure 12.6. First determine the following:

12.3.1.2.1. Glide Path. Typically this is 3 degrees, but may vary at some locations.

12.3.1.2.2. Threshold Crossing Height (TCH). See table 3.3. For the Air Force, the TCH is based on the most predominant aircraft using the runway (the Major Command will make this determination). For the Army, the TCH is based on the most demanding aircraft height group expected to use the runway (the aviation community will coordinate with USAASA for this determination).

12.3.1.2.3. Runway Gradient. This may be available from record drawings, or determined by field survey. Usually the grade is given as a percent representing the vertical elevation difference over a longitudinal distance (threshold through approximate PAPI location). For example, a 1% grade represents a 0.3 meter (12 inch) height difference over a 30 meter (100 feet) length. This is converted to an angle in degrees, α , using the relationship: $\tan \alpha = \% \text{ grade (expressed as decimal)}$. With this relationship, a grade of 1% represents a runway slope of 0.573 degrees (from the horizontal).

12.3.1.3. Determine the Runway Reference Point (RRP) based on runway gradient, as shown in figure 12.6, establishing the RRP where the elevation of the lens center of the light units coincides with the elevation of the runway centerline. The method provides a direct solution, based on two equations and two unknowns, when the grade of the runway is relatively uniform. The RRP is based on the PAPI light beam, where the elevation of the lens center of the PAPI light units intercept the ground elevation along the runway centerline (within tolerance). Case 4 in figure 12.6 provides an iteration method for locating the RRP when the runway grade varies significantly through the first approximately 450 meters (1,500 feet).

12.3.1.4. Adjust the location of the PAPI for cross slope or other factors, as required. Several examples of how the location of the RRP or location of the PAPI might be adjusted are presented below. Stay within allowable tolerances and other dimensional requirements of paragraph 12.3.2. See figure 12.7 for guidance on tolerances and adjustments if PAPI can not be located at the RRP.

12.3.1.4.1. Where the terrain drops off rapidly near the approach threshold and severe turbulence is typically experienced, it would be beneficial to locate the RRP and PAPI farther from the threshold if sufficient runway length is available. In this case consider using the maximum TCH allowed by tolerance in determining the RRP.

12.3.1.4.2. On shorter runways, the RRP and PAPI may be located nearer the threshold to provide the maximum amount of runway for braking after landing. In this case consider using a lower TCH as allowed by tolerance in determining the RRP.

12.3.1.4.3. At locations where snow is likely to obscure the light beams, the light units may be installed so the top of the unit is a maximum 2 meters (6 feet) above ground level. This may require locating the light units farther from the runway edge to ensure adequate clearance for the most critical aircraft. If the light beams are higher than the allowable tolerance, with respect to the elevation of the runway centerline (raising the TCH for the visual glide path), the PAPI may be relocated closer to the threshold to maintain the RRP and TCH.

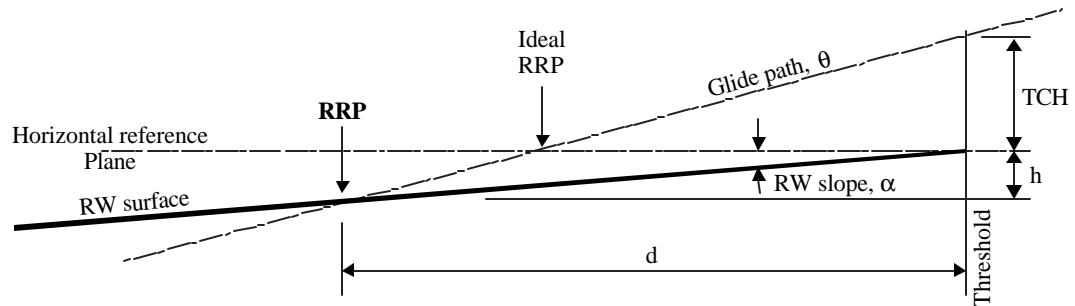
12.3.1.4.4. The cross slope at the preliminary RRP location may result in the light units sitting too high or too low with respect to the runway centerline elevation. In such cases, the PAPI may be relocated closer to or farther from the threshold in order to maintain the RRP and TCH and remain within tolerance.

12.3.2. Other Dimensions and Tolerances.

12.3.2.1. Distance from Runway Edge. Install the inboard PAPI light unit no closer than 15 meters, +3 meters –0 meters (50 feet, +10 feet –0 feet) from the runway edge, or from the edge of other runways or taxiways.

Figure 12.6. Siting PAPI without an ILS Glide Slope (1 of 2).

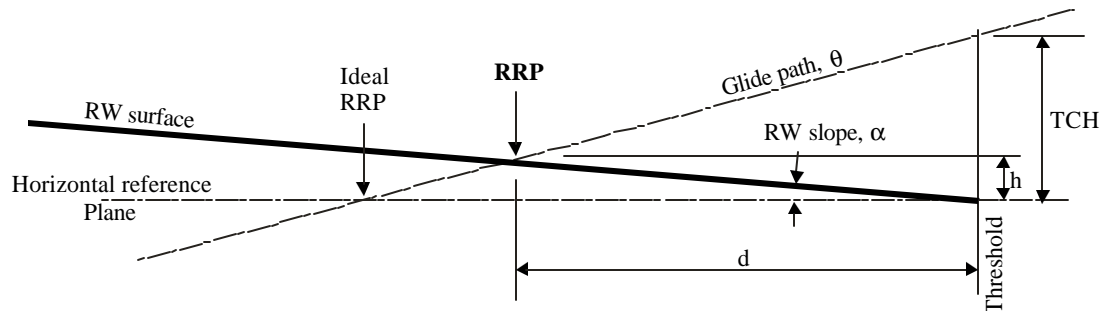
a. Case 1 - Runway with downward grade.



Two relationships can be defined which have two unknowns (d, h): $\tan \theta = \frac{TCH + h}{d}$, and $\tan \alpha = \frac{h}{d}$

Substituting and solving the above, d is determined directly by: $d = \frac{TCH}{(\tan \theta - \tan \alpha)}$

b. Case 2 - Runway with upward grade.



From the above relationships, d is determined directly by: $d = \frac{TCH}{(\tan \theta + \tan \alpha)}$

EXAMPLES (Assume the following: TCH = 15 meters (50 feet), $\theta = 3$ degrees)

Case 1 (RW with 1% downward grade, $\alpha = 0.573$ degrees) $\Rightarrow d = 50 / [\tan 3 \text{ degrees} - \tan 0.573 \text{ degrees}] = \underline{360 \text{ meters (1,179 feet)}}$

Case 2 (RW with 1% upward grade, $\alpha = 0.573$ degrees) $\Rightarrow d = 50 / [\tan 3 \text{ degrees} + \tan 0.573 \text{ degrees}] = \underline{244 \text{ meters (801 feet)}}$

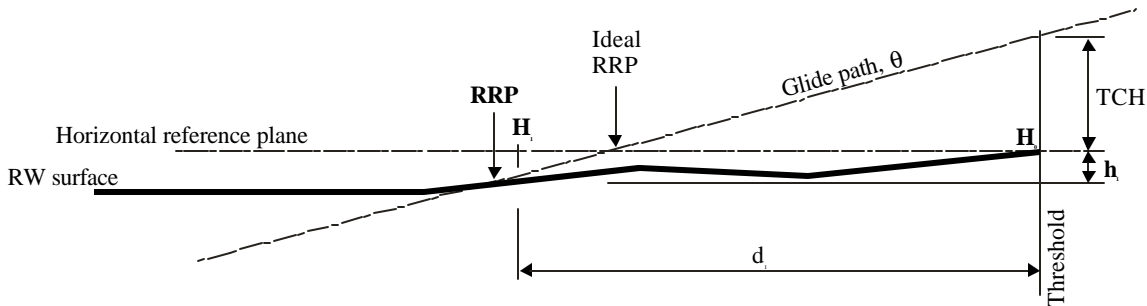
Case 3 (RW is level - 0% grade, α and $\tan \alpha$ are both 0) $\Rightarrow d = 50 / [\tan 3 \text{ degrees}] = \underline{290 \text{ meters (954 feet)}}$
[not illustrated]

While the slope should be constant through the first part of a runway, if the existing slope varies too much to directly apply Case 1, 2 or 3, then a trial method illustrated by Case 4 can be used. In all cases, the location of the glide path intercept with the actual runway surface (RRP) must be determined.

Case 4 - Runway grade varies too much to apply above methods \Rightarrow [See sheet 2 of 2]

Figure 12.6. Siting PAPI without an ILS Glide Slope (2 of 2).

c. Case 4 - Runway with varying grade.



Use this method if longitudinal runway grade changes within 671 meters (2200 feet) from the runway threshold. Consider that a 0.1% change in runway grade at about 150M (500) from threshold translates to a 15cm (6") change in elevation at 300M (1,000), and about a 3M (10) error in calculating the RRP, using the runway grade beginning at the threshold. The trial method requires elevation data along the runway centerline in proximity of the PAPI site.

(1) Select a trial value for d ("d"). [Case 1 or Case 2 can be used to select initial trial value].

(2) At distance d, determine elevation difference from threshold ($H - H = h$)

(3) Test d and h in following equation:
$$\frac{TCH + h}{d} =? \tan \theta$$

NOTE: $\tan \theta = 0.0524$ for glide path angle of 3° .]

(4) If value in (3) is larger than $\tan \theta$, then increase d, determine new h, and test equation in (3). If value is smaller than $\tan \theta$, then decrease d, determine new h, and test equation in (3). Continue until within about $\pm .0001$ of $\tan \theta$ [this yields a value for "d" within about $\pm 2'$ of where RRP should be located]

EXAMPLE Case 4 (Assume the following: TCH = 50', $\theta = 3^\circ$).

At d = 950', h = 4.2', and $(TCH+h)/d = 0.0571$ (too large)

At d = 1,000', h = 4.6', and $(TCH+h)/d = 0.0546$ (closer)

At d = 1,050', h = 5.0', and $(TCH+h)/d = 0.0524$ (matches $\tan \theta$ - OK)

[NOTE: Suggested longitudinal tolerance for locating PAPI is + or - 10']

Example data from field survey

Point	Station	d	H	h
Thld, 0	0+00	0	110.4'	-
1	9+50	950'	114.6'	4.2'
2	10+00	1,00'	115.0'	4.6'
3	10+50	1,050'	115.4'	5.0'

DEFINITIONS:

RRP = RW reference point, where PAPI is located based on adjustment for runway grade.

Ideal RRP = RW reference point if runway has 0% grade (no slope).

RW = Runway

TCH = Threshold crossing height

d = Distance PAPI is located from runway threshold, based on adjustment for runway grade.

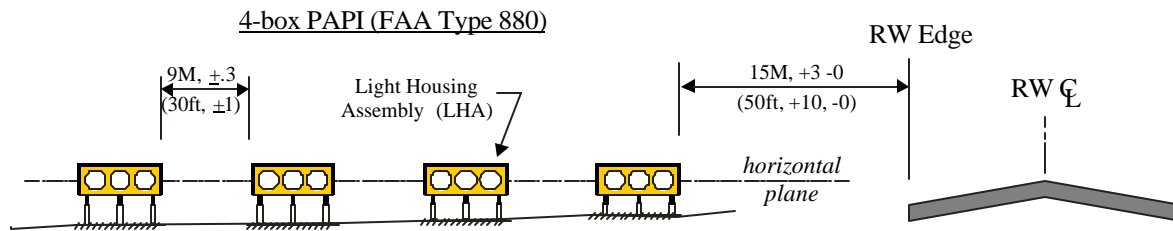
θ = Glide path angle, degrees (from horizontal).

α = Runway slope, degrees (use positive value in above equations).

h = Elevation (height) difference between RW threshold and RRP, measured on RW centerline surface.

H = Elevation at a point along runway centerline.

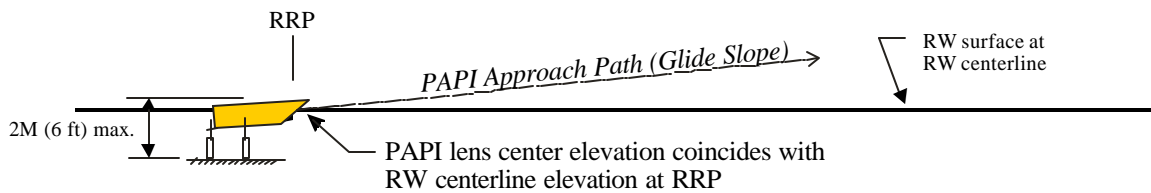
Figure 12.7. PAPI Positioning Guidance.



PAPI is located so that center of lenses are level with RW centerline at RRP (Runway Reference Point) within following tolerances:

- $\pm 0.3M$ (1 ft) of RW elevation (lens or beam intercept plane with RW centerline at RRP)
- ± 25 mm (1 in) between LHAs (lens centers of one LHA with lens centers of another)

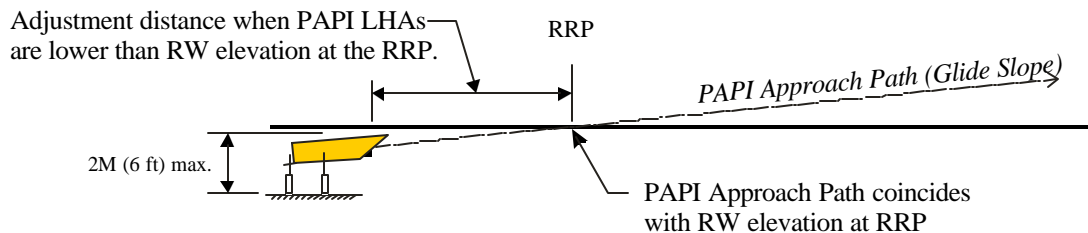
PAPI FRONT (APPROACH) VIEW



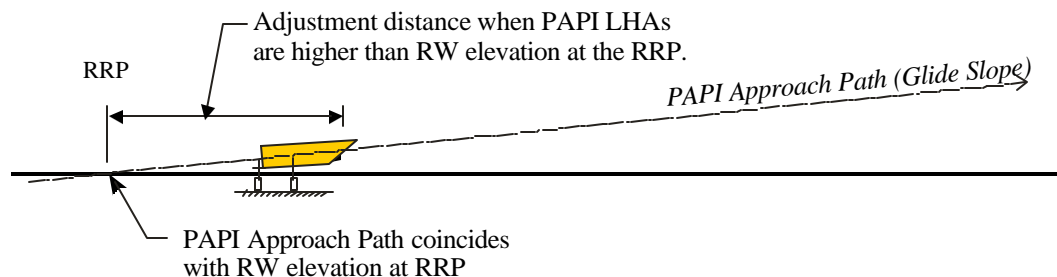
PAPI SIDE VIEW

ADJUSTMENTS TO PAPI LOCATION (see also paragraph 12.3.1.4)

A. When lens is **below** RW elevation at RRP.



B. When lens is **above** RW elevation at RRP.



NOTE: See also paragraph 3.7.4 and Figure 3.16.

12.3.2.2. Separation Between Light Units. Provide lateral separation of 9 meters (30 feet) between light units. This may be reduced to no less than 6 meters (20 feet) if warranted by conditions. The distance between light units must be equal and not vary by more than 0.3 meters (1 foot).

12.3.2.3. Azimuthal Aiming. Aim each light unit towards the approach zone on a line parallel to the runway centerline, within a tolerance of ± 0.5 degree.

12.3.2.4. Mounting Height Tolerance. The beam centers of the four light units must be within ± 2.5 centimeters (± 1 inch) of a horizontal plane. This plane must be within ± 0.3 meters (± 1 foot) of the elevation of the runway centerline at the intercept point of the visual glide path with the runway (RRP), except for adjustments under conditions in paragraph 12.3.1.4, items 3 and 4.

12.3.2.5. Tolerance Along Line Perpendicular to Runway. The front face of each light unit in a bar must be located on a line perpendicular to the runway centerline within a tolerance of ± 15 centimeters (± 6 inches).

12.3.2.6. Vertical Aiming of Light Beams. For 4-box L-880 PAPI, the units are aimed as shown in table 12.3.

Table 12.3. Aiming of FAA Type L-880 PAPI Relative to Glide Path.

Light Unit	Aiming angle (in minutes of arc)	
	Standard installation	Height Group 4 aircraft on Runway with ILS
Unit nearest runway (#1)	30' above glide path	35' above glide path
Next adjacent unit (#2)	10' above glide path	15' above glide path
Next adjacent unit (#3)	10' below glide path	15' below glide path
Next adjacent (outside) unit (#4)	30' above glide path	35' below glide path

12.4. Pulling Cable Into Duct:

12.4.1. Pull cable into ducts carefully to prevent harmful stretching of the conductor, injury to the insulation, or damage to the outer protective covering. Duct should be verified as open, continuous, and free of debris prior to installing cable. The following summarizes guidance for pulling cable from FAA Specification FAA-C-1391, *Installation and Splicing of Underground Cable*. This document may be referenced for additional information.

12.4.2. Seal all cable ends with moisture-sealing tape before pulling, and maintain seals until connections are made. All cables to be installed in one duct should be pulled at the same time. Splices should not be pulled into a duct.

12.4.3. Apparatus for pulling cable at entrances to structures may include a pulling tube or framework and two sheaves. The diameter of the sheaves should be at least 10 times the diameter of the largest cable to be pulled. Cable may be pulled by power winch or by hand. Adequate cable pulling compound should be used of an approved type (do not use petroleum grease).

12.4.4. Structures such as manholes, handholes, junction boxes, and light bases are typically spaced so as to avoid excessively long cable pulls. The spacing should not exceed 180 meters (600 feet), and spacing not more than 120 – 150 meters (400 – 500 feet) is preferred.

12.4.5. If possible, the maximum allowable cable length to be pulled should be obtained from the cable manufacturer. An estimate of the absolute maximum length of pull based on new, level, straight plastic duct and the use of adequate pulling compound is as follows:

$$L = T \times KW$$

Where: L = Length of cable pulled (in feet)

T = Total tension (in pounds)

K = Coefficient of friction (0.3 for single cables, 0.4 for multiple cables)

W = Weight of all cables being pulled (in pounds/foot)

12.4.6. A dynamometer should be used to monitor the cable tension during pulling. Alternatively, a contractor may adapt a rope harness properly sized to limit pull tension. Types and sizes for ropes used in this manner may be found in FAA-C-1391 table 1. Manufacturer's data on allowable cable pulling tension should always be used. Any combination of a group of cables to be pulled into a duct must not exceed the sum of individual allowable tension of each cable plus 15 percent. Typical examples of the allowable maximum tension for various types of cable are shown in table 12.4.

Table 12.4. Maximum Allowable Non-Armored Cable Pulling Tension, Using Dynamometer.

CABLE	TENSION KG (LB.)
2 – 1/C #8 solid	125 (275)
3 – 1/C #8 solid	167 (367)
4 – 1/C #8 solid	250 (550)
2 – 1/C #6 stranded	191 (420)
3 – 1/C #6 stranded	286 (630)
4 – 1/C #6 stranded	382 (840)
1 – 2/C #8 stranded	139 (305)
1 – 3/C #8 stranded	180 (395)
1 – 4/C #8 stranded	266 (585)
1 – 2/C #6 stranded	207 (455)
1 – 3/C #6 stranded	311 (685)
1 – 4/C #6 stranded	400 (880)
1 – 6/C #12 stranded	143 (315)
1 – 12/C #12 stranded	286 (630)
1 – 12 pair #19 solid	105 (230)
1 – 25 pair #19 solid	246 (541)
1 – 50 pair #19 solid	482 (1061)
1 – 100 pair #19 solid	909 (2000)

12.4.7. The pressure on a cable or cables being pulled is affected by a radius or bend in a duct. For non-straight segments of duct the following, based on manufacturer information, is recommended as a guide in limiting the tension with duct radius (T is the maximum allowable pulling tension, and R is the radius of the duct):

$$T(\text{kg}) / R(\text{m}) \leq 456 [T(\text{lbs}) / R(\text{ft}) \leq 300]$$

12.5. Ice Damage Prevention. Water in light bases is very common. In cold regions placing several 51 millimeter by 203 millimeter (2 by 8 inch) closed cell foam disks in the light base will help prevent ice damage to the base, light fixture and isolation transformer.

Chapter 13

QUALIFYING EQUIPMENT

13.1. General Equipment Requirements. This chapter covers equipment and equipment specifications which meet the standards in the first part of this document. The chapter includes only those items covered by the associated standards and does not include cables, auxiliary or main power generating systems, or common use items such as convenience outlets or interior electrical fixtures.

13.2. Existing Facilities. Do not use this document as a sole basis for advancing standards of existing facilities and equipment, except where necessary for a minimum acceptable level of safety, quality, and performance. You may continue to support existing systems with equipment fabricated to the original specifications until the system is upgraded. If mixing of new generation equipment with older equipment is required, make sure the difference in performance does not degrade the system in any way.

13.3. Equipment Specifications. The equipment specifications used in this chapter fall into two broad categories: FAA Advisory Circulars (AC) and FAA-E Series specifications (FAA-E-XXXX). Use the latest edition of a specification if the performance requirements continue to satisfy the appropriate standard in part one of this regulation. If specifications are canceled and replaced by specifications with new numbers, use the new specification if the applicable standards of this regulation are met. FAA standards specify the minimum requirements for equipment. For some products, options or characteristics available from manufacturers that are in addition to or exceed FAA requirements have been shown important to achieving proper or improved system performance. Information on additional characteristics or more selective criteria for some items can be found in paragraph 13.16. It is suggested that the designer consider these additional requirements, as appropriate, in specifying equipment for new installations.

13.4. Qualified Products. The FAA maintains lists of manufacturers of products meeting Advisory Circular specifications. For equipment meeting FAA Advisory Circular specifications use FAA AC 150/5345-53, *Airport Lighting Equipment Certification Program*. Qualification or approval in listing does not mean automatic acceptance of the equipment for a particular project. Satisfactory evidence of the production tests, such as certification of compliance by ETL Testing Laboratories or other approved third party certifiers, included in the specifications is required for acceptance for each project. There are no qualified product lists

for equipment manufactured to FAA-E specifications. Information concerning current sources of this equipment may be obtained from regional FAA offices and manufacturers' product literature. The specified production tests are also required for these products.

13.5. Commercial Equipment. Commercial equipment, not covered by appropriate military or FAA specifications, must meet applicable industry standards such as the National Electrical Manufacturers Association (NEMA) or Institute of Electrical and Electronic Engineers (IEEE). Contract documents must specify the methods for verifying conformance.

13.6. Alternative Equipment. You may consider equipment using new technologies but must make sure the standards in this document are met; cost effectiveness, reliability, availability, maintainability, and service life are not compromised; and adequate training and logistic support for the substitute equipment is available. The waiver requirements of paragraphs 1.8 and 1.9 apply. See also paragraph 13.16.

13.7. Emergency Substitution. In emergency situations where facility restoration would be significantly delayed by non-availability of replacement parts, equipment or devices not meeting the applicable specifications may be substituted. Base Civil Engineering, airfield operations, and flying safety offices must all coordinate these substitutions and notify the Major Command. Remove the substitute equipment from service and replace it with approved equipment as soon as it becomes available.

13.8. Common Use Airfield Lighting Equipment. This paragraph lists equipment commonly used in most or all airfield lighting system installations. Wherever required, listed equipment conforming to the cited specifications may be used. Other special application equipment is specified in the paragraphs covering the particular lighting system involved:

13.8.1. Control Panels. For Army facilities, use panels meeting FAA AC 150/5345-3, *Specification for L-821 Panels for Control of Airport Lighting*, Type L-821. For Air Force facilities, tower design constraints or special air traffic controller requirements may dictate the use of other types of control panel. Recommended design for new systems or major upgrades include newer types of controls such as Touch-screen and computerized, except as rejected by the FAA.

13.8.2. Pilot Relay Cabinets. Use cabinets meeting FAA AC 150/5345-13, *Specification for L-841 Auxiliary Relay Cabinet Assembly for Pilot Control of Airport Lighting Circuits*, Type L-841 for 48 VDC control systems.

13.8.3. Series Circuit Selector Switches. Use switches in accordance with FAA AC 150/5345-5, *Circuit Selector Switch*, Type L-847.

13.8.4. Control Cables. Control cables for 120 VAC control systems must be multi-conductor, 600 volts, 12 AWG copper, rated for direct earth burial. Cables for 48 VDC control circuits must be multi-conductor, stranded 19 AWG copper, with 300 volt polyvinyl insulation suitable for installation in wet locations and meeting REA Bulletin 345-14 or 345-67. Color code all conductors.

13.8.5. Current Regulators. Use regulators meeting FAA AC 150/5345-10, *Specification for Constant Current Regulators and Monitors*, of a suitable type and style. The size selected should normally provide for approximately 20 percent expansion of the load.

13.8.6. Engine/Generators. Use engine/generators meeting Specification FAA-E-2204 with Type I automatic power transfer. Also see AFI 32-1063, *Electric Power Systems*, and AFMAN 32-1184, *Operation, Maintenance, and Repair of Electric Power Generating Plants and Systems*.

13.8.7. Series Cable Selection. Cables must be unshielded, 5000 volt FAA AC 150/5345-7 (Latest Issue) L-824 cable. Series cables (medium voltage, 5000 volt) must not be installed in cable trays unless they are rated type C (TC).

13.8.8. Connectors. Use connectors meeting FAA AC 150/5345-26, *Specification for L-823 Plug and Receptacle, Cable Connectors*, for L-823 plug and receptacle cable connectors to interconnect fixtures, isolation transformers, and distribution cables.

13.8.9. Isolation Transformers. Use isolation transformers meeting FAA AC 150/5345-47, *Isolation Transformers for Airport Lighting Systems*. When specifying, ensure the input/output currents are compatible with the regulator and current rating of the lamp.

13.8.10. Mounting Bases and Transformer Housings. Use bases meeting FAA AC 150/5345-42, *Specification for Airport Light Bases, Transformer Housings, Junction Boxes and Accessories*. When specifying FAA type bases, use Type L-867 for non-traffic areas (such as elevated light systems located on the edges of runways and taxiways) and Type L-868 for load bearing applications (subject to loading by aircraft, including overruns) containing lights that are embedded in the pavement. Unless otherwise specified non-metallic bases may be used in non-load bearing applications. Ensure the base and fixture are compatible.

13.8.11. Frangible Supports. If frangible mounting is required and the device is not provided with an integral fracture mechanism, mount the device on electric metallic tubing (EMT) or intermediate metallic conduit attached to the mounting base by a frangible coupling meeting FAA Drawing C-6046A, *Frangible Coupling Type I and Type IA, Details*.

13.8.12. Fixtures, Filters and Lamps. Use fixtures and lamps as specified for each system. If more than one fixture is connected to an isolation transformer, the fixture must have a shorting device or bypass relay to avoid multiple light outage if a lamp fails. Filter colors must meet the latest FAA Advisory Circular criteria, also refer to the CIE color coordinate diagram. (See figure 13.1.)

13.9. Equipment for Approach Light Systems. In-pavement approach lights in overrun areas use FAA Type L-850E fixtures which are red or white as required.

13.9.1. High Intensity Approach Light System ALSF-1. See paragraph 3.1.

13.9.1.1. Pre-threshold Bar. Use fixtures meeting FAA-E-982 with red filters figure 13.2).

13.9.1.2. Terminating Bar. Use fixtures meeting FAA-E-982 with red filters. (See figure 13.2.)

13.9.1.3. 1,000-foot Crossbar. Use fixtures meeting FAA-E-982 with no filter. (See figure 13.2.)

13.9.1.4. Centerline Light (Barrettes). Use fixtures conforming to FAA AC 150/5345-46, type L-850E without filters. (See figure 13.3.)

13.9.1.5. Centerline Light (Barrettes). For stations 10+00 to station 30+00 and unpaved end zone areas use fixtures meeting FAA-E-982 without filters. (See figure 13.2.)

13.9.1.6. Approach Threshold Lights. Use fixtures conforming to FAA AC 150/5345-46, type L-850E with green filters. (See figure 13.3.)

13.9.1.7. Sequence Flashing Lights SFL. Use fixtures meeting FAA-E-2628 Type I or conforming to FAA AC 150/5345-51, *Specification for Discharge-Type Flasher Equipment*, type L-849 Style E. (See figure 13.5.)

13.9.2. High Intensity Approach Light Systems ALSF-2. See paragraph 3.2. This system is a modified ALSF-1 system, the following areas have additional light fixtures:

13.9.2.1. 500 Foot Bar. Use fixtures conforming to FAA AC 150/5345-46, type L-850E without filters. See figure 13.3.

13.9.2.2. Side Row lights. Use fixtures meeting FAA-E-982, with red filters. (See figure 13.2.)

13.9.3. Short Approach Lighting System (SALS). This system is a shortened version of the ALSF-1 system with the same fixtures as in figure 13.2 used.

13.9.4. Simplified Short Approach Light System with Runway Alignment Indicators (SSALR). This system is a simplified version of the ALSF-1 and ALSF-2 systems, the same fixture as in figures 13.2 and 13.3 are used.

13.9.5. Medium Intensity Approach Light System with Runway Alignment Indicator lights (MALSR), See paragraph 3.5.

13.9.5.1. Centerline light barrettes, use fixtures meeting FAA-E-2325, PAR 38 lamp holders. (See figure 13.6.)

Figure 13.1. CIE Color Coordinate Diagram.

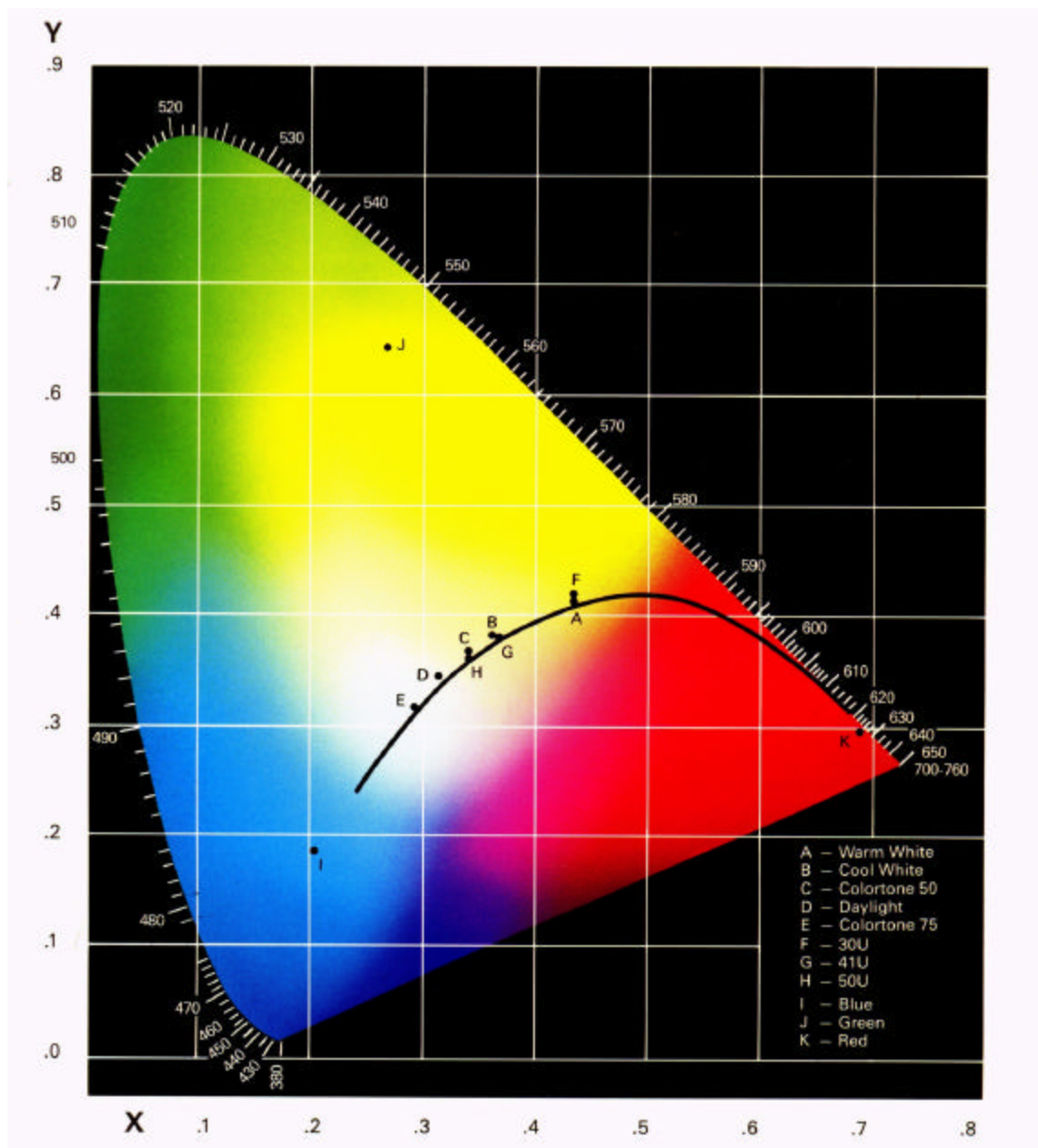
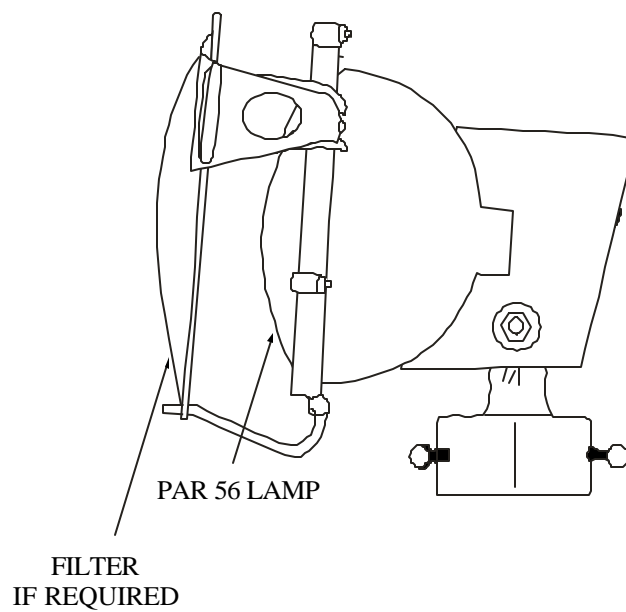


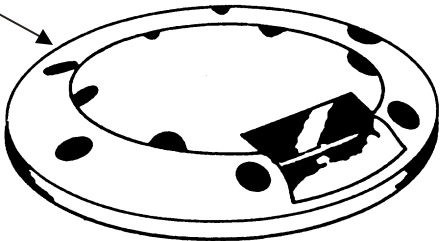
Figure 13.2. FAA-E-982, Elevated, Uni-directional, PAR-56, Lamp Holder.



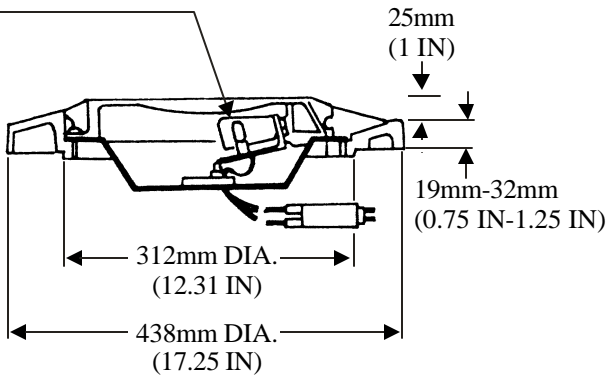
TRANSFORMER: 200W, 6.6/6.6A,
FAA AC 150/5345-47, TYPE L-830-5

Figure 13.3. FAA-L-850E, In-pavement, Uni-directional.

IN-PAVEMENT UNI-DIRECTIONAL
FAA AC 150/5345-46 TYPE L-850E

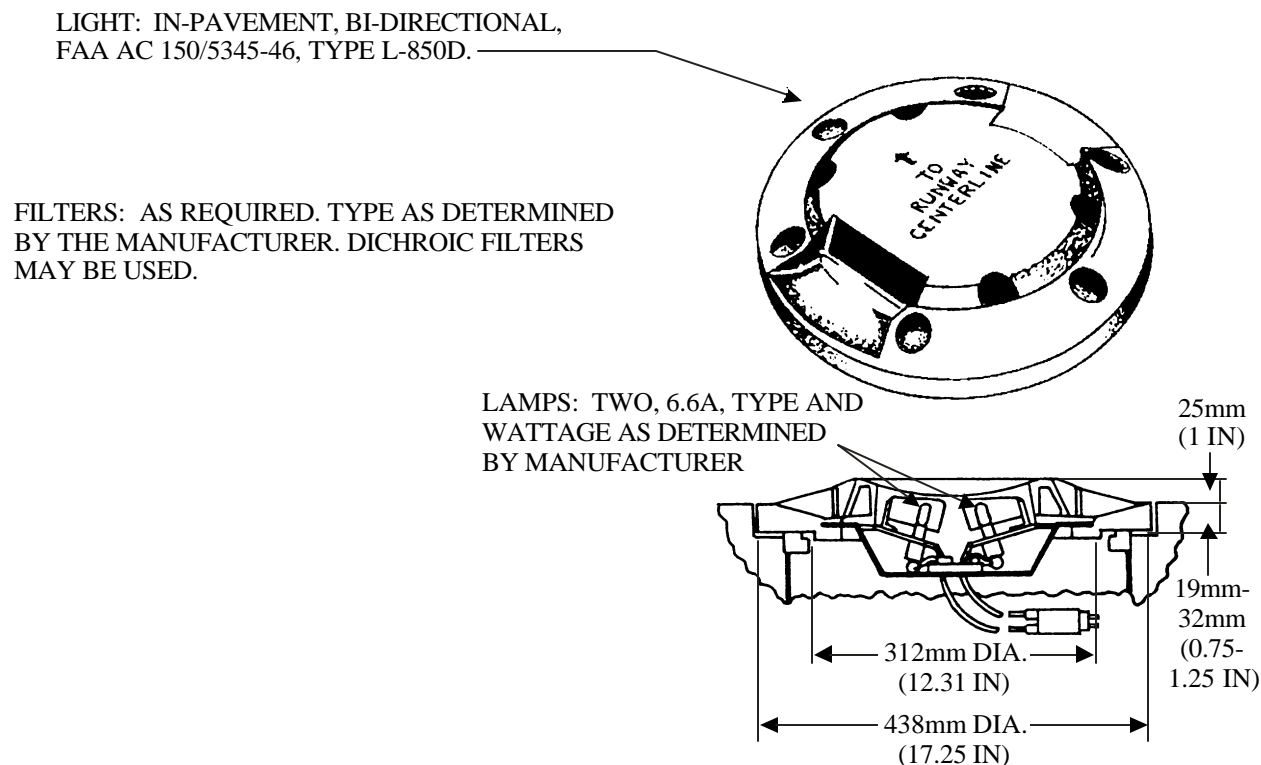


LAMP: ONE OR TWO LAMPS,
TYPE AS DETERMINED BY MANUFACTURER



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Figure 13.4. FAA-L-850D, In-pavement, Bi-directional.



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13.9.5.2. 1,000-foot Crossbar. See paragraph 13.9.5.1.

13.9.5.3. Runway Alignment Indicator Lights (RAIL). Use fixtures conforming to FAA AC 150/5345-51, type L-849E. (See figure 13.5.)

13.9.5.4. Paved Areas. When the system is installed in a paved over run area, use fixtures conforming to FAA AC 150/5345-46, type L-850B. (See figure 13.7.)

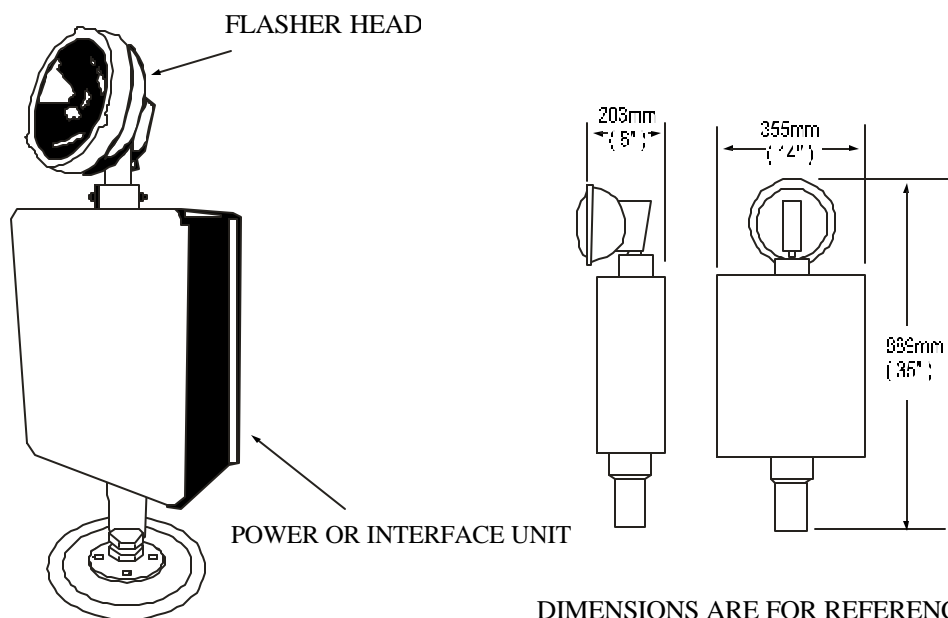
13.9.5.5. General Lamp Guidelines. Use lamps recommended by the manufacturer to meet the requirement. Different manufacturers may meet the requirement using different lamps. In the interest of energy conservation, the lower wattage lamps are preferred. When using lamps rated at 6.6 amps, they must be connected to individual 6.6/20A isolation transformers. When using lamps rated at 20A, they must be connected to individual 20A/20A isolation transformers. Use 200W isolation transformers, or as otherwise recommended by the lamp manufacturer. If the overall mounting height is greater than 2 meters (6 feet), the lights in a bar must be connected in series to the transformer specified in paragraph 13.9.5.7. Fixtures connected in series to a single isolating transformer must have bypass relays to bypass failed lamps.

13.9.5.6. Light Fixture Supports, 0 to 12 meters (40 feet).

13.9.5.6.1. For mounting light fixtures up to 2 meters (6 feet) above ground level, use 0.05 meters (2 inch) diameter EMT which is fitted at the bottom with a frangible coupling conforming to FAA Drawing C-6046.

13.9.5.6.2. For light fixtures elevated between 2 meters (6 feet) and 12 meters (40 feet) above ground level, use glassfiber low impact resistant (LIR) frangible support structures meeting FAA-E-2702 and FAA Drawing Series D-6155, *ALSF-2, 6' to 128' and MALS, 40' to 128' LIR Structures*.

Figure 13.5. FAA-E-2628, or FAA L-849E, Elevated, Condenser Discharge (Sequenced Flashing Light).



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OUTLINE DIMENSIONS

LIGHT: SEQUENCE FLASHING, ELEVATED,
FAA-E-2628, OR FAA AC 150/5345-51,
TYPE L-849 STYLE E.

LAMP: PAR56, FLASH TUBE,
TYPE AS DETERMINED BY
MANUFACTURER

POWER OR INTERFACE UNIT:
TYPE AS DETERMINED BY
MANUFACTURER

MASTER CONTROLLER:
(NOT SHOWN) AS DETERMINED
BY MANUFACTURER

Figure 13.6. FAA-E-2325, Elevated, Uni-directional, PAR-38 Lamp Holder.

LAMPHOLDER: PAR-38, OUTDOORS,
COMMERCIAL TYPE AS DETERMINED
BY THE MANUFACTURER.

LAMP: 120V 120W PAR-38
TYPE 120PAR/SP ENERGY SAVING,
OR 120V 150W PAR-38
TYPE 150PAR/SP.

POWER UNIT: (NOT SHOWN) DISTRIBUTION
VOLTAGE TO 120V RATED, 3-INTENSITY
SETTINGS AS REQUIRED BY MANUFACTURER
(ONE UNIT FOR SYSTEM)

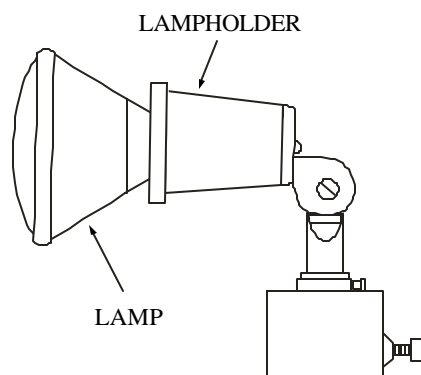
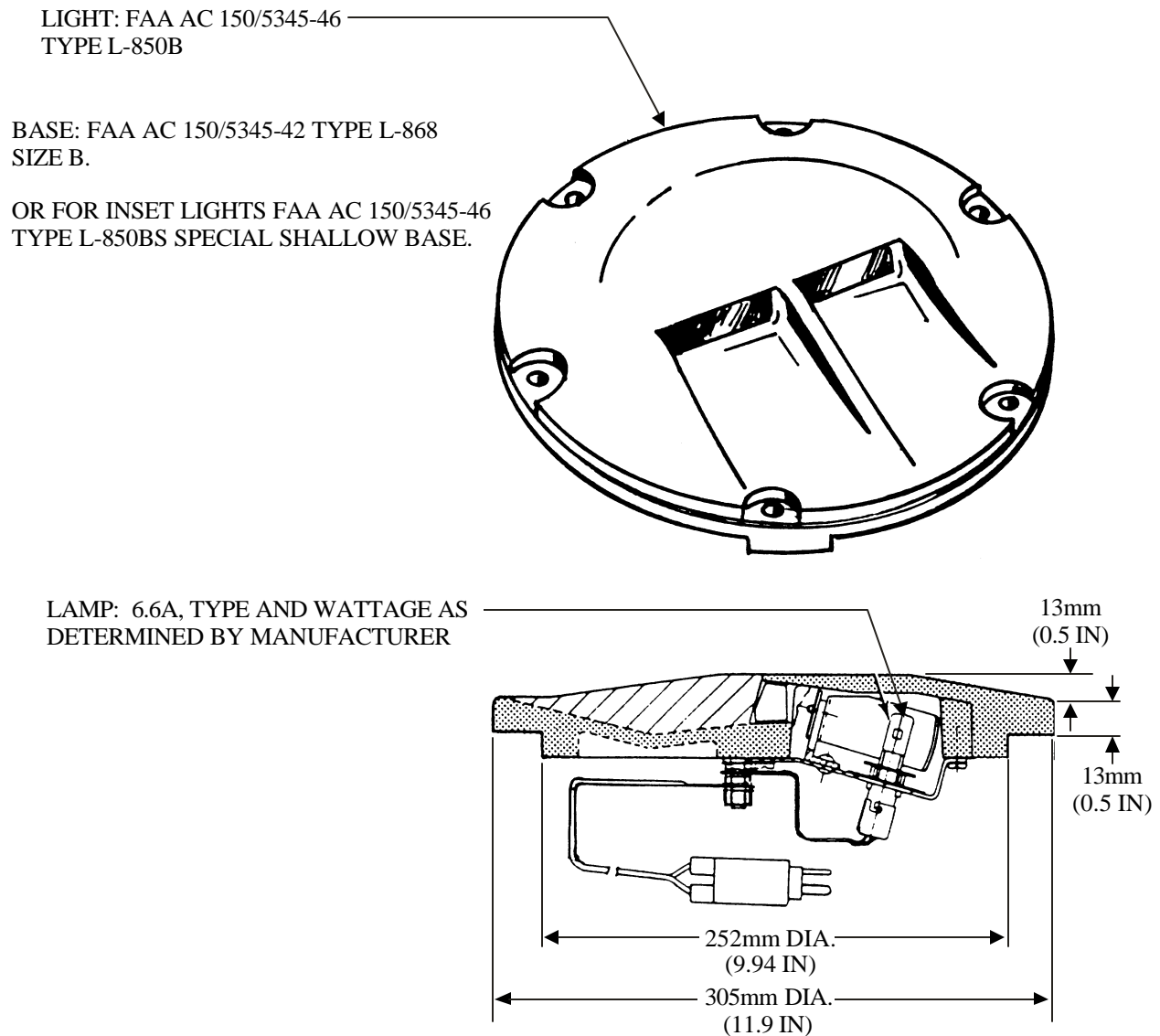


Figure 13.7. FAA-L-850B, In-pavement, Uni-directional.



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NOTE: TOE-IN THE LIGHT BEAM TOWARD THE RUNWAY CENTERLINE

13.9.5.7. Rigid Supports, over 12 meters (40 feet). For rigid supports for fixtures over 12 meters (40 feet) above ground level, use a structural steel tower with a 6 meter (20 feet) LIR fiberglass mast supporting the cross bar (MS-20 assembly), which lowers vertically through the rigid tower platform for maintenance of the light fixtures. A diagram of a rigid tower with MS-20 assembly is provided in UFC 3-535-02. Tower manufacturer should have at least 10 years continuous experience in the fabrication of structural steel towers. An acceptable tower is the SSV series rigid steel tower manufactured by ROHN Industries, or equivalent. The manufacturer should develop the tower design details based on height and load requirements, certified by a structural engineer. The rigid steel tower should have the following minimum characteristics:

13.9.5.7.1. Designed for the appropriate wind speed and ice load based on latest revision of ANSI/EIA-222, *Structural Standards for Steel Antenna Towers and Antenna Supporting Structures*.

13.9.5.7.2. Steel pipe and solid rod legs with minimum yield strength of 345 MPa (50 ksi). Braces, plates and bolts must be of size and strength required by design. Welding must be by AWS Gas Metal Arc Process, by AWS certified welders.

13.9.5.7.3. Hot-dipped galvanized inside and out, after fabrication, in accordance with ASTM A123, *Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products E1-1998*, for structural materials and ASTM A-153, *Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Products E1-1998*, for hardware.

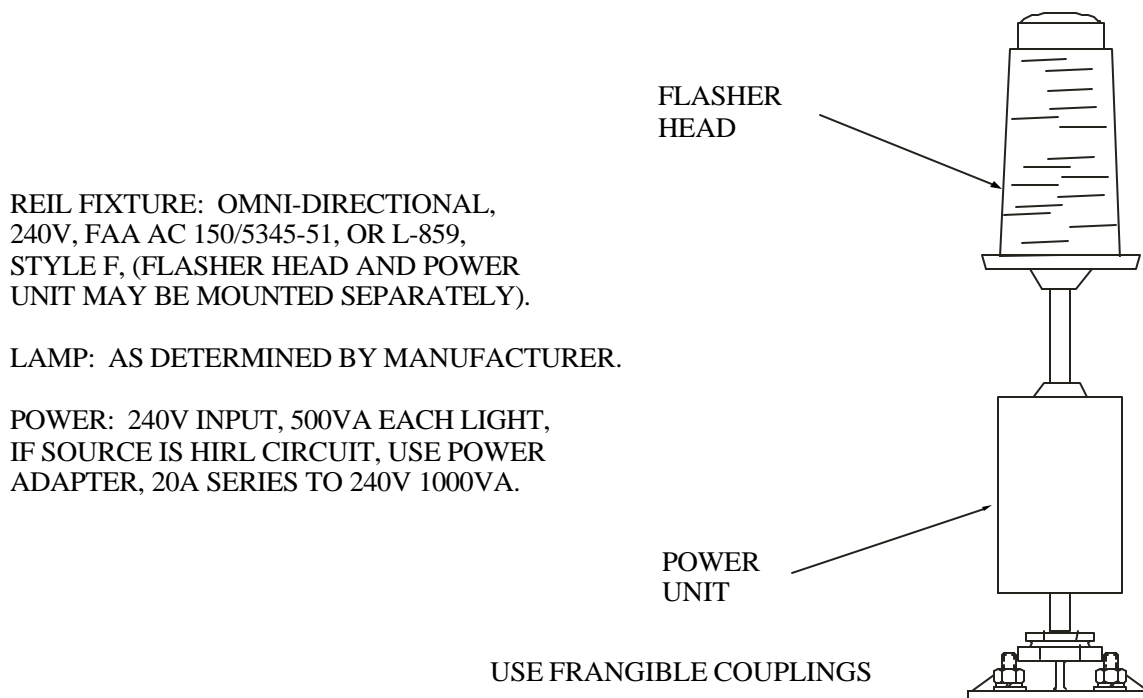
13.9.5.7.4. Service platform to be fabricated of the same materials as the tower. Platform must accommodate the safe movement and activity of maintenance personnel (via railing or gate/trap door, for example) and the mounting and lowering of the telescoping LIR mast. The working facilities (such as platform, hand or guardrails) must meet the latest revision of ANSI/EIA-222.

13.9.5.7.5. Service ladder must include a safety climbing device (e.g., rigid rail or cable style hook-up) for the safe ascent/descent of maintenance personnel. The service ladder must be a fixed ladder meeting the latest revision of ANSI/EIA-222, and climbing device must meet the requirements of ANSI A14.3-1984, *Fixed Safety Requirements for Ladders*.

13.9.5.7.6. Foundation design must, as a minimum, be adequate for a 190 kPa (4,000 psf) soil bearing capacity, and must be adequate to meet the maximum reaction loads of the tower as defined by the tower designer.

13.9.6. Runway End Identifier Lights (REIL). See paragraph 3.6. Use equipment meeting FAA-E-2628 or FAA AC 150/5345-51, Type L-859F for omni-directional REIL installations. (See figure 13.8.)

Figure 13.8. FAA-L-859F, Omni-directional, Flashing.



13.9.7. PAPI/CHAPI. See paragraphs 3.7 and 7.6. Use equipment meeting FAA-E-2756, *Four Box PAPI*, or FAA AC 150/5345-28, type L-880, *Precision Approach Path Indicator (PAPI) Systems*, or *Chase Helicopter Approach Path Indicator (CHAPI) System*, Equipment and Installation. (See figure 13.9.)

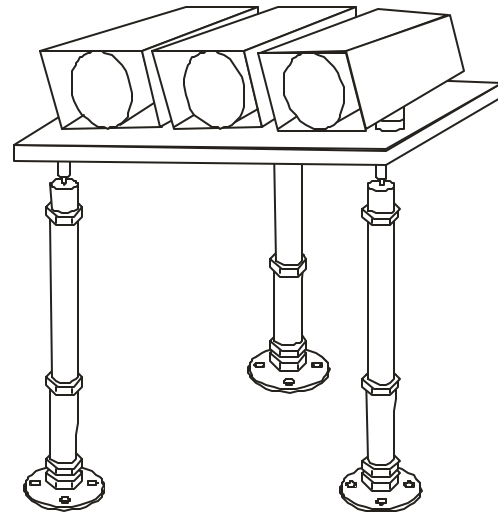
Figure 13.9. FAA L-880, or FAA-E-2756, PAPI or CHAPI System.

LIGHT SOURCE UNIT: FAA AC 150/5345-28,
TYPE L-880 OR L-881 OR FAA-E-2756

LAMP: TWO OR THREE 6.6A, TYPE AS
REQUIRED BY MANUFACTURER.

ISOLATION TRANSFORMER: TWO OR
THREE 6.8/6.6A FAA AC 150/5345-47 TYPE
AS REQUIRED FOR WATTS.

USE FRANGIBLE COUPLINGS



13.10. Equipment for Runway Lighting Systems:

13.10.1. High Intensity Runway Edge Lighting Equipment. See paragraph 4.2.

13.10.1.1. Elevated Fixtures. Use light fixtures meeting FAA AC 150/5345-46, Type L-862. (See figure 13.10.) Colored filters, where required for displaced threshold areas, must meet the requirements of the specification and be compatible with the fixture. Use lamps recommended by the manufacturer. Different manufacturers may meet the requirement using different lamps. In the interest of energy conservation, lower wattage lamps are preferred.

13.10.1.2. In-pavement Fixtures. Use fixtures meeting FAA AC 150/5345-46, Type L-850C. (See figure 13.11.) Use lamps recommended by the manufacturer. Different manufacturers may meet the requirement using different lamps. In the interest of energy conservation, lower wattage lamps are preferred.

13.10.2. Medium Intensity Runway Edge Lights. See paragraph 4.3.

13.10.2.1. Elevated Fixtures. Use fixtures meeting FAA AC 150/5345-46, Type L-861. (See figure 13.12.) In displaced threshold areas, provide colored filters meeting the specification and compatible with the fixture.

13.10.2.2. In-pavement Fixtures. Use bi-directional fixtures meeting FAA AC 150/5345-46, Type L-852B without filters. (See figure 13.13.) Use lamps recommended by the manufacturer. Different manufacturers may meet the requirement using different lamps. In the interest of energy conservation, lower wattage lamps are preferred.

13.10.3. High Intensity Threshold Lighting. See paragraph 4.4.

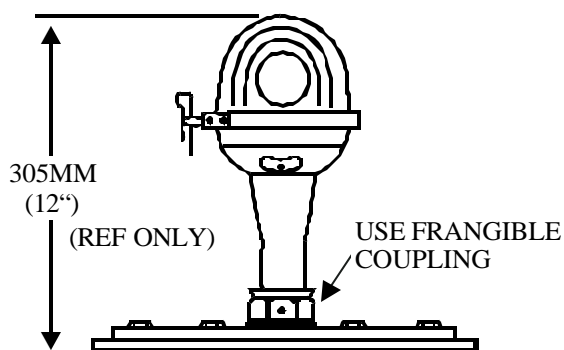
13.10.3.1. In-pavement Fixtures, Uni-directional, Green or Red. Use light fixtures meeting FAA AC 150/5345-46, Type L-850E. (See figure 13.3.) FAA Type L-850D do not meet the threshold light photometric requirements so are not acceptable. (See figure 4.5.)

13.10.3.2. Medium Intensity Threshold and End Lights. Use fixtures meeting FAA AC 150/5345-46, Type L-852D, with red and green filters where bi-directional runway end/threshold fixtures are required. If uni-directional light is required use a blank on the side not needed. (See figure 13.13.)

13.10.3.3. Elevated Light Fixtures. Use fixtures meeting FAA AC 150/5345-46 Type L-862.

13.10.4. Runway End Lights (High Intensity). See paragraph 4.6.

Figure 13.10. FAA L-862, Elevated, Bi-directional.



LIGHT: ELEVATED HIRL FAA AC 150/5345-46
TYPE L-862

LAMP: 6.6A, TYPE AND WATTAGE AS SPECIFIED
BY MANUFACTURER.

TRANSFORMER: FAA AC 150/5345-47 TYPE L-830-7.
IF FOR 6.6A PRIMARY CIRCUIT, 200W, 6.6/6.6A

OR

FAA AC 150 5345-47 TYPE L-830-6

MAY BE MOUNTED ON LIGHT BASE OR CONDUIT
USE FRANGIBLE COUPLING.

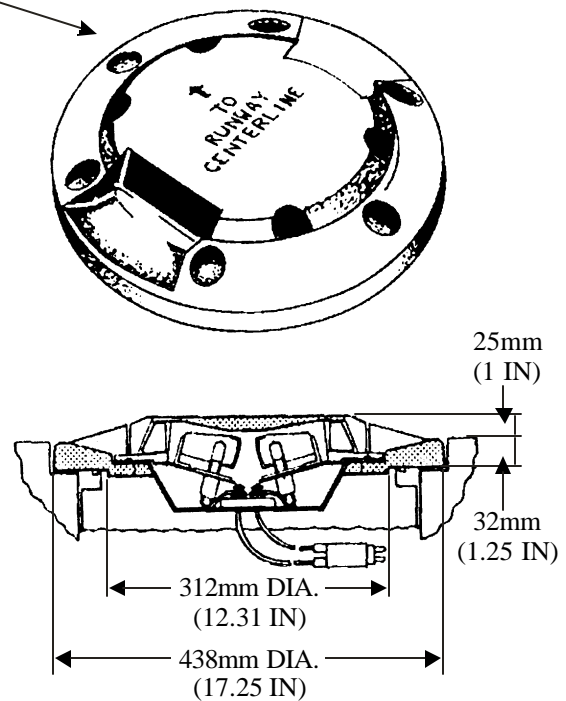
Figure 13.11. FAA L-850C, In-pavement, Bi-directional.

LIGHT: IN-PAVEMENT HIRL
FAA AC 150/5345-46 TYPE L-850C

LAMP: TWO, 6.6A, TYPE AND WATTAGE
AS SPECIFIED BY MANUFACTURER.

BASE: 381mm (15 IN) DIAMETER, FAA AC 150/5345-42
TYPE L-868 SIZE C.

FOR TWO 150W LAMPS, FAA AC 150/5345-47 TYPE
L-830-11 OR ONE 300W 6.6/6.6A, FAA AC
150/5345-47 TYPE L-830-10.



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Figure 13.12. FAA L-861, Elevated, Omni-directional.

LIGHT: ELEVATED FAA AC 150/5345-46,
TYPE L-861, OMNI-DIRECTIONAL, YELLOW
OR WHITE DEPENDING ON APPLICATION.

LAMP: 6.6A, TYPE AND WATTAGE AS
DETERMINED BY MANUFACTURER.

ISOLATION TRANSFORMER: 6.6/6.6A,
45 WATTS, FAA AC 150/5345-47, TYPE L830-1.

MOUNT ON FRANGIBLE COUPLING.

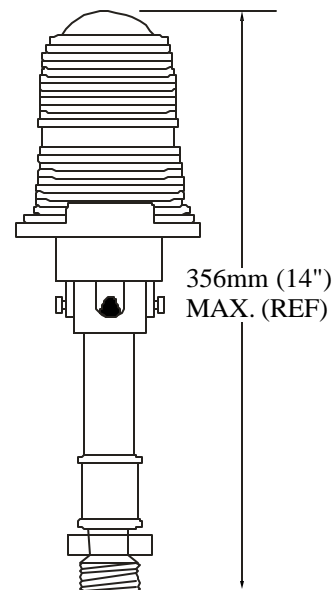
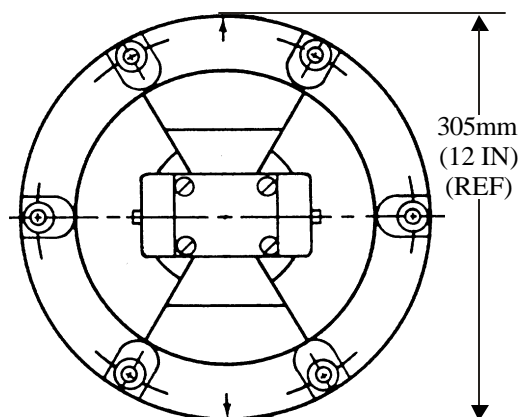
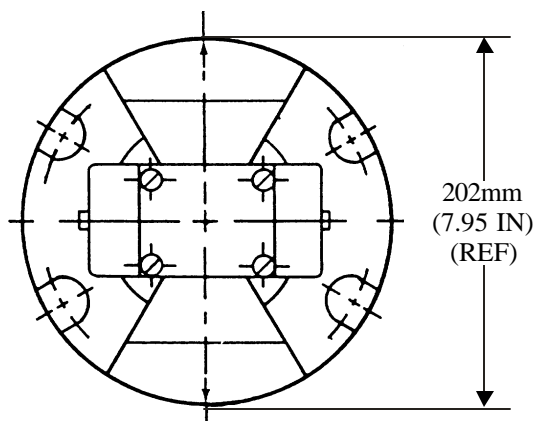


Figure 13.13. FAA L-852, (A, B, C, D), In-pavement, Bi-directional.

LIGHT: SEMI-FLUSH, BI-DIRECTIONAL OR UNI-DIRECTIONAL, FAA AC 150/5345-46 TYPE L-852A,B,C, OR D, AS DETERMINED FOR NARROW-BEAM, WIDE-BEAM, OR CATEGORY III.

LAMP: 6.6A, WATTS AND TYPE AS DETERMINED BY THE MANUFACTURER.

FILTERS: AVIATION COLORS, TYPE AS DETERMINED BY APPLICATION.



13.10.4.1. Light Fixtures, In-pavement, Uni-directional, Red. Use fixtures meeting FAA AC 150/5345-46, Type L-850E with red filter where threshold and runway ends are not relocated. (See figure 13.3.)

13.10.5. Medium Intensity Threshold/End Lighting (Army only.). See paragraph 4.4.

13.10.5.1. In-pavement Fixtures, Bi-directional, Red/Green (Army only). Use light fixtures meeting FAA AC 150/5345-46, L-852D, when combination runway end light/threshold lights are required. (See figure 13.13.)

13.10.5.2. Elevated, Bi-directional, Red/Green. Use light fixtures meeting FAA AC 150/5345-46, L-861SE, when elevated combination runway end light/threshold light are required. (See figure 13.14.)

13.10.6. Runway Centerline Lights (RCL). See paragraph 4.7. Use fixtures meeting FAA AC 150/5345-46, Type L-850A, Class I or II. Use red filters where required to meet the requirements in paragraph 4.7. (See figure 13.15.)

Figure 13.14. FAA L-861SE, Elevated, Bi-directional.

LIGHT: ELEVATED FAA AC 150/5345-46,
TYPE L-861SE, BI-DIRECTIONAL, RED/
GREEN.

LAMP: 6.6A, TYPE AND WATTAGE AS
DETERMINED BY MANUFACTURER.

ISOLATION TRANSFORMER: 6.6/6.6A,
100 WATTS, FAA AC 150/5345-47, TYPE L830-1.

MOUNT ON FRANGIBLE COUPLING.

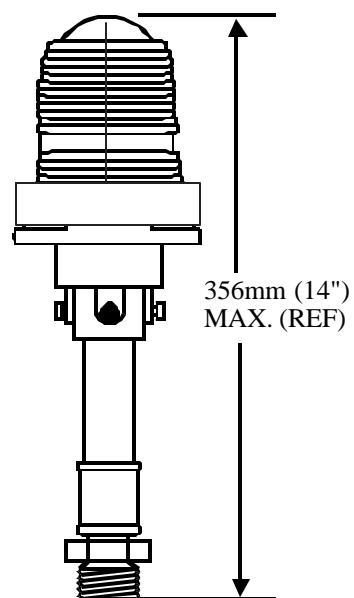


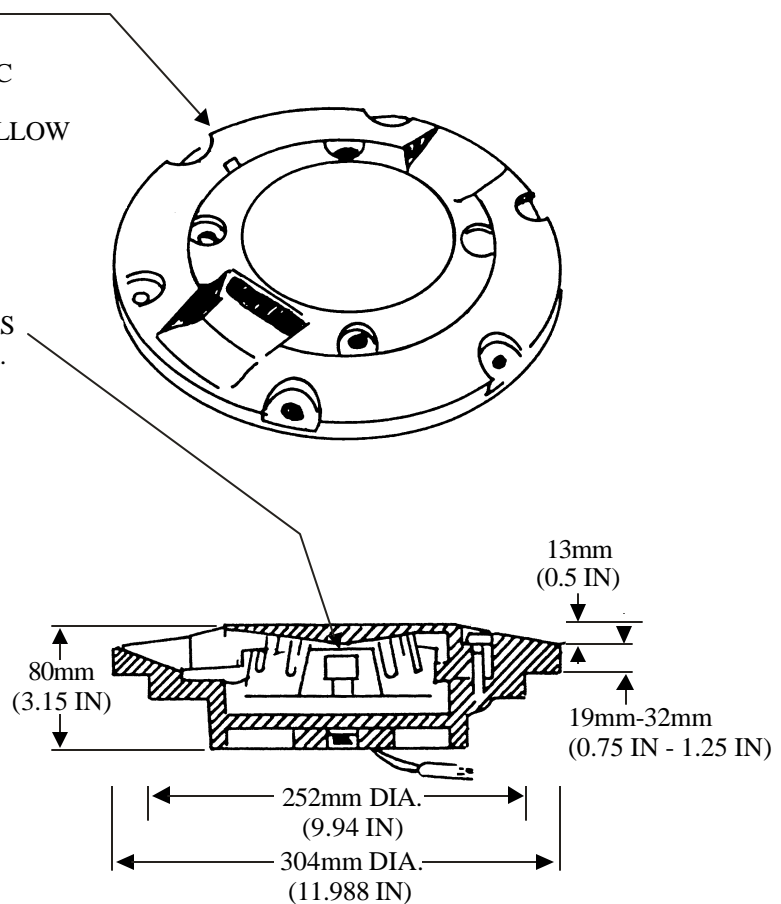
Figure 13.15. FAA L-850A, In-pavement, Bi-directional.

LIGHT: BASE-MOUNTED TYPE FAA AC 150/5345-46 TYPE L-850A.
 LIGHT: DIRECT-MOUNTED TYPE FAA AC 150/5345-46 TYPE L-850AS. SAME LIGHT EXCEPT EQUIPPED WITH SPECIAL SHALLOW INSET BASE.

LAMP: 6.6A, TYPE AND WATTAGE AS DETERMINED BY MANUFACTURER.

FILTER: AVIATION RED, AS REQUIRED.

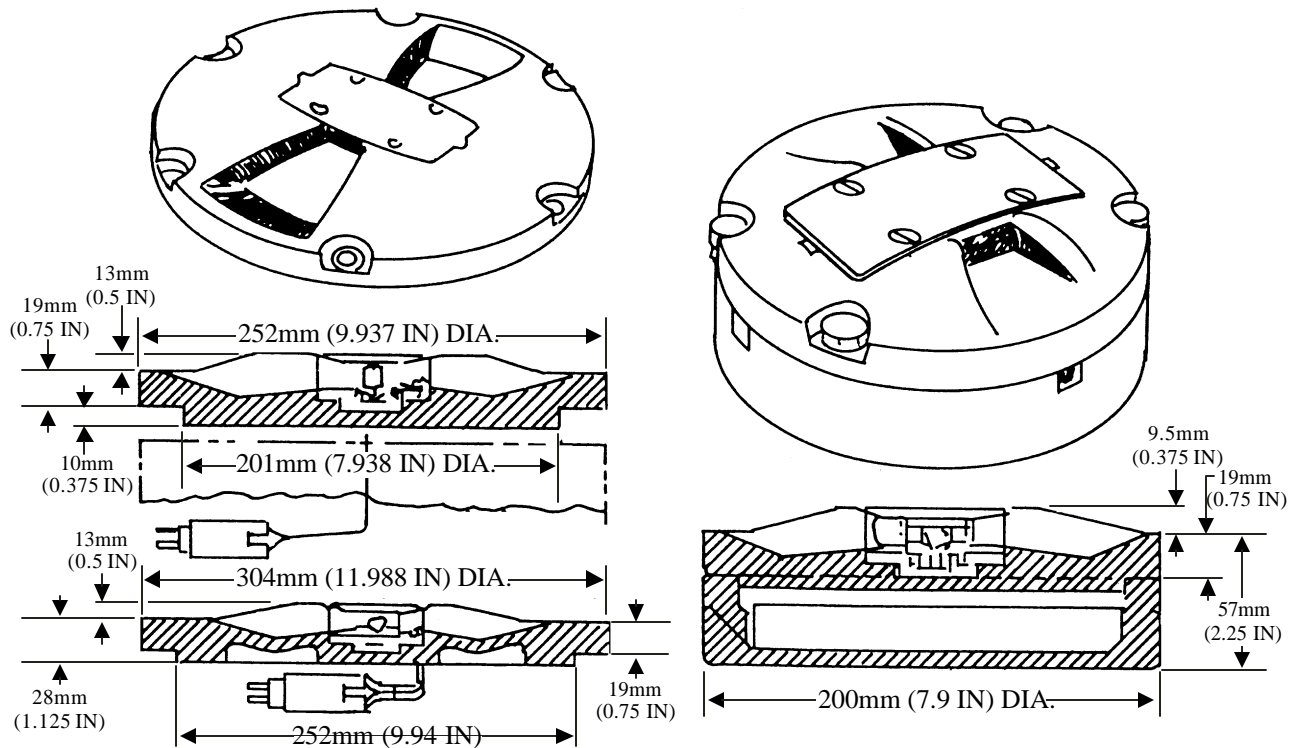
BASE: FAA AC 150/5345-42 TYPE L-858
 SIZE B, 305mm (12 IN) DIA.



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13.10.6.1. Where centerline lights are subject to aircraft tail hook impact use a high strength steel design designated as L-852N (NAVY). (See figure 13.16.)

Figure 13.16. FAA L-852N, In-pavement, Bi-directional (Hook-resistant).



NOTE: DIMENSIONS ARE FOR REFERENCE ONLY

LIGHT, BASE MOUNTED: TYPE L-852N NAVY
TYPE VII OR VIII, WITH SHORTING DEVICE
FOR FAILED LAMP

LIGHT, DIRECT MOUNTED: TYPE L-852N NAVY
TYPE VI, WITH SHORTING DEVICE FOR
FAILED LAMP

LAMP: 6.6A, TYPE AND WATTAGE AS DETERMINED
BY MANUFACTURER

FILTER: AVIATION RED OR WHITE, AS REQUIRED

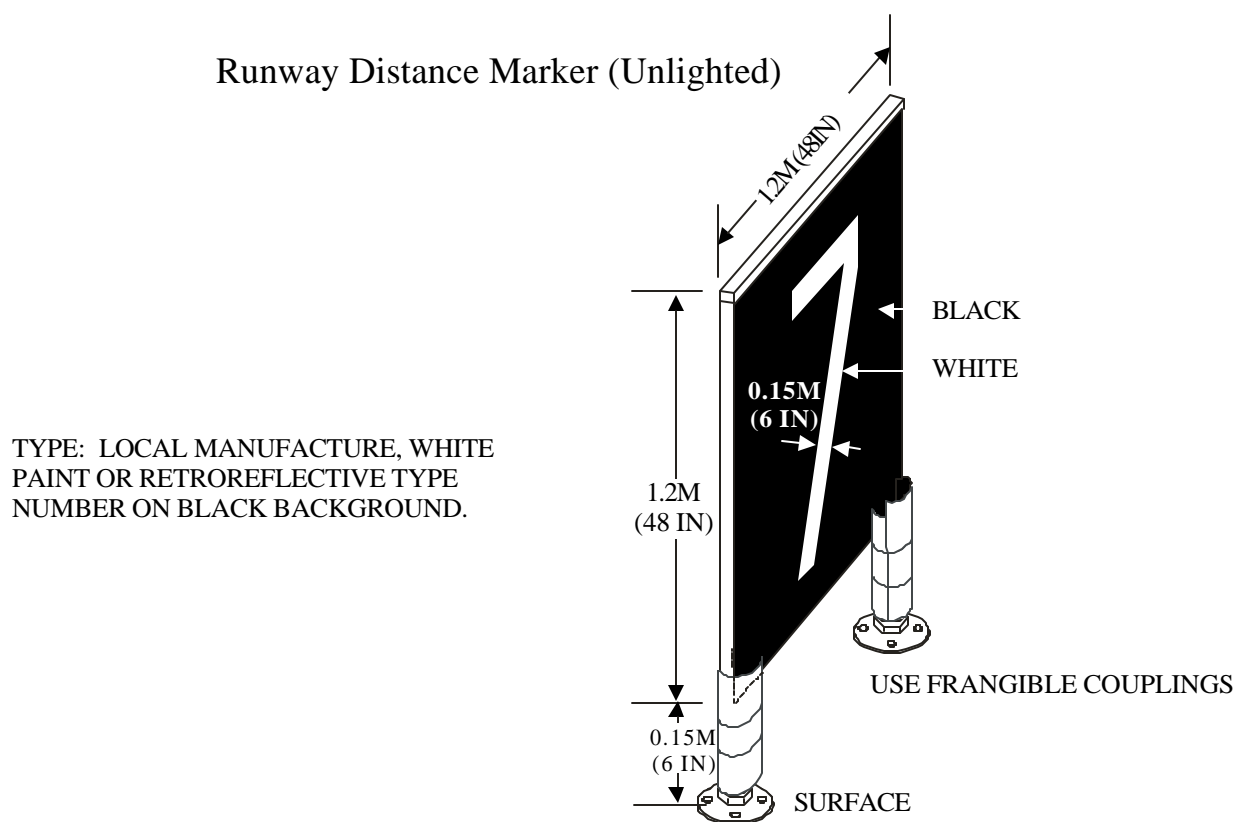
BASE: FAA AC 150/5345-42 TYPE L-858 SIZE A
254mm (10 IN) DIA. FOR LIGHT TYPE VII OR
SIZE B 305mm (12 IN) FOR LIGHT TYPE VIII

BASE: SPECIAL SHALLOW FOR DIRECT
MOUNTED LIGHTS BY MANUFACTURER

13.10.7. Touchdown Zone Light (TDZ). See paragraph 4.8. Use fixtures meeting FAA AC 150/5345-46, Type L-850B, Class I or II. (See figure 13.7.)

13.10.8. Runway Distance Markers (RDM). See paragraph 9.6. Use markers meeting FAA AC 150/5345-44, Type L-858B, size 4. When connected to the runway lighting circuits, specify style 3. (See figure 13.17.)

Figure 13.17. Runway Distance Markers.



Runway Distance Marker (Illuminated)

MARKER: FAA AC 150/5345-44, TYPE L-858B, SIZE 4, STYLE 3.

LAMP: TYPE AS DETERMINED BY MANUFACTURER.

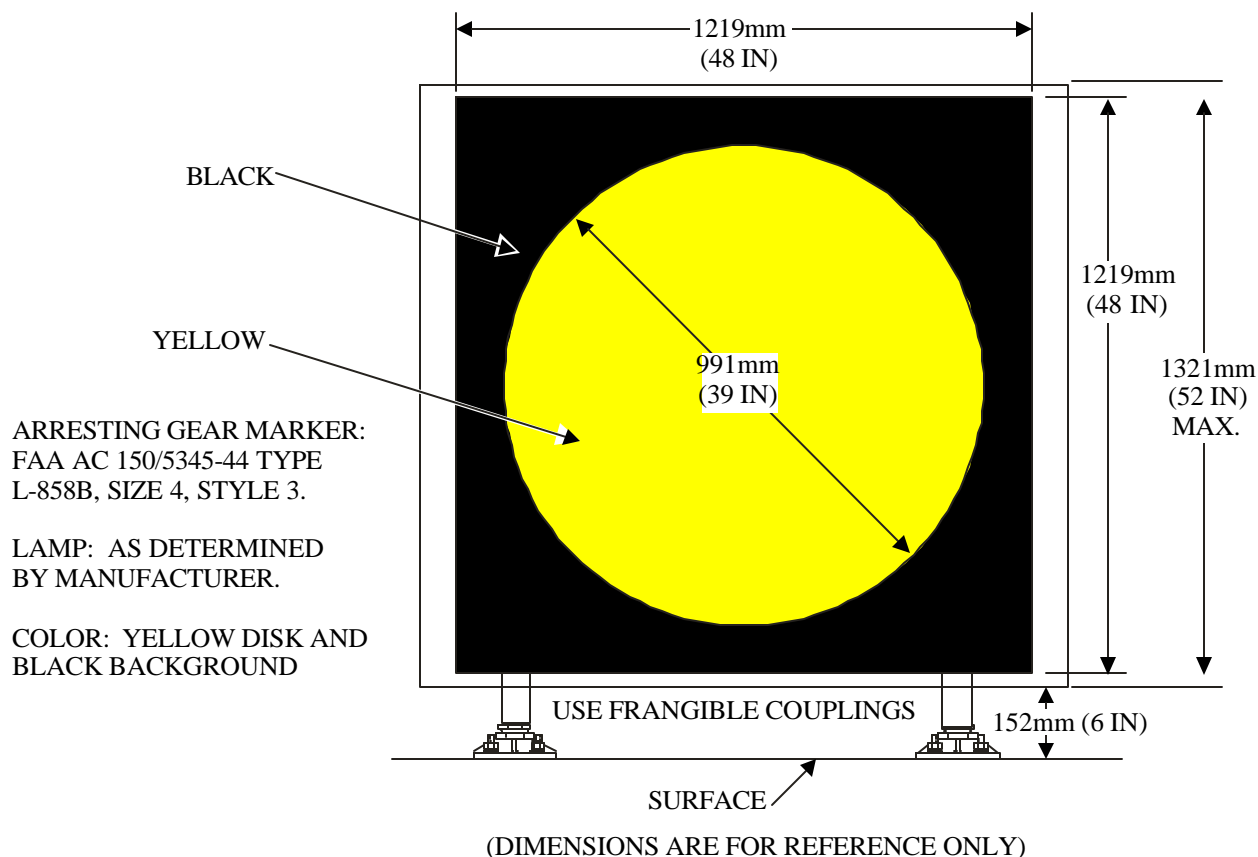
ISOLATION TRANSFORMER: RATING AS DETERMINED BY THE MANUFACTURER.

COLOR: WHITE NUMERALS ON A BLACK BACKGROUND OR FOR EXISTING INSTALLATIONS YELLOW NUMERALS ON A BLACK BACKGROUND.



13.10.9. Arresting Gear Markers (AGM). See paragraph 9.7. These markers are a modified RDM with a yellow circle in lieu of a number. (See figure 13.18.)

Figure 13.18. FAA L-858B, Sign, Elevated, AGM.



NOTE: BASE MARKER MAY BE TRIANGULAR OR RECTANGLE.

13.11. Equipment for Taxiway Lighting Systems:

13.11.1. Taxiway Edge Lights, Elevated Fixtures. See paragraph 5.1. Use light fixtures meeting FAA AC 150/5345-46, Type L-861T. (See figure 13.19.) Use lamps recommended by the manufacturer to meet the requirements of paragraph 5.1. Different manufacturers may meet the requirement using different lamps. In the interest of energy conservation, lower wattage lamps are preferred. Where an in-pavement taxiway edge light is needed use an FAA AC 150/5345-46, type L-852E.

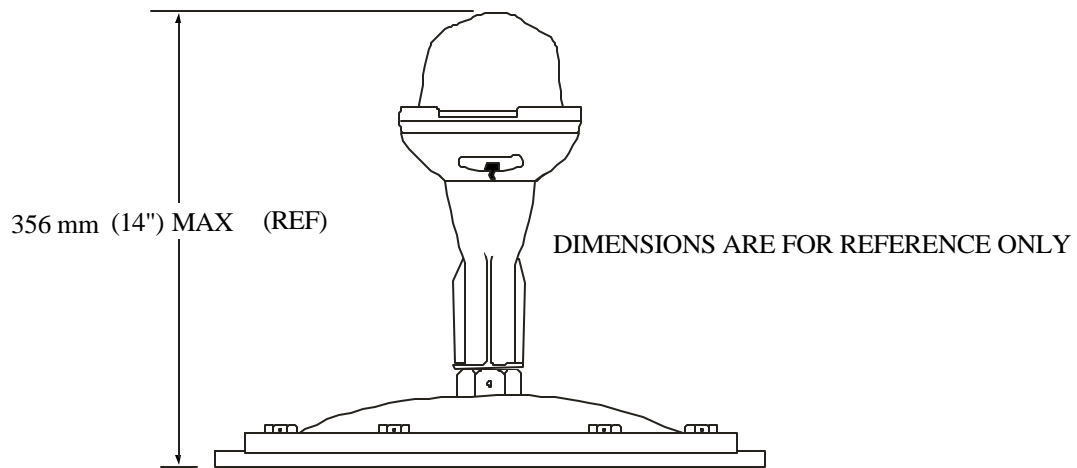
13.11.2. Taxiway Centerline, Hold Point and High Speed Turnoff Lighting. See paragraphs 5.2 and 5.4. (See figure 13.20.)

13.11.2.1. Fixtures. Use fixtures meeting FAA AC 150/5345-46, Type L-852, Class I or II. These fixtures may be direct inset, for mounting on special shallow bases, or for mounting on 250 or 300 millimeter (10 or 12 inch) base housings. Select fixtures by type depending on application.

13.11.2.1.1. Straight Centerline Sections. For Category II and higher operations, use FAA AC 150/5345-46 Type L-852A with green/green filters except at hold bars where the filter facing the holding aircraft will be yellow. For Category III application, use FAA AC 150/5345-46 Type L-852C.

13.11.2.1.2. Curved Centerline Sections. For Category II and higher operations, use FAA AC 150/5345-46 Type L-852. Where small radius turns require aiming along a chord for proper viewing, two fixtures may be used. For Category III applications, use FAA AC 150/5345-46 Type L-852D.

Figure 13.19. FAA L-861T, Elevated, Omni-directional.



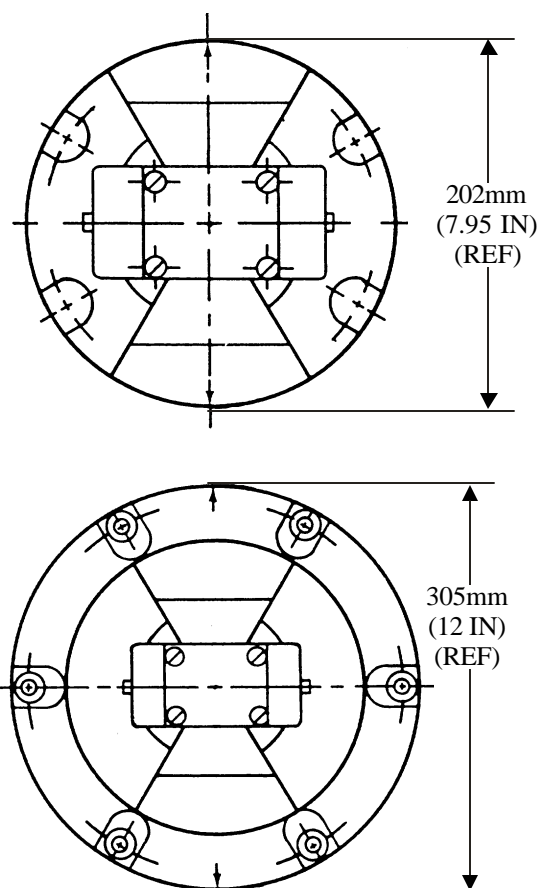
LIGHT: ELEVATED, 45W 6.6A, FAA AC 150/5345-46, TYPE L-861T, BLUE
LAMP: 6.6A, WATTS AS SPECIFIED, TYPE AS DETERMINED BY MANUFACTURER
AVIATION COLORS AS REQUIRED FOR APPLICATION
ISOLATION TRANSFORMER: 30/45W 6.6/6.6A
FAA AC 150/5345-47, TYPE L-830-1
MOUNTED ON FRANGIBLE COUPLING, MAY BE EITHER ON LIGHT BASE OR CONDUIT.

Figure 13.20. FAA L-852, In-pavement, Bi-directional, Uni-directional.

LIGHT: IN-PAVEMENT, BI-DIRECTIONAL OR UNI-DIRECTIONAL, FAA AC 150/5345-46 TYPE L-852A,B,C, OR D, AS DETERMINED FOR NARROW-BEAM, WIDE-BEAM, OR CATEGORY III.

LAMP: 6.6A, WATTS AND TYPE AS DETERMINED BY THE MANUFACTURER.

UNI-DIRECTIONAL LIGHTS ARE PROVIDED BY BLANKING OUT ONE BEAM.



13.11.2.1.3. Clearance Bar (Hold Point) Semi-flush. Use Type FAA AC 150/5345-46, L-852A with yellow filter for side lights at hold bar arrays for Category II and higher operations. For Category III applications, use FAA AC 150/5345-46, Type L-852C.

13.11.2.1.4. Runway Guard Lights Elevated. See paragraph 5.5. Use FAA-L-804 elevated fixture. For semi-flush see paragraph 13.11.2.1.3. (See figure 13.25.)

13.11.2.1.5. High Speed Turnoff. For Category II and higher operations, FAA AC 150/5345-46, Type L-852 uni-directional with green filter may be used on straight sections and L-852B uni-directional on curved sections. Use Types L-852C and 852D for Category III applications.

13.11.2.1.6. Lamps. Use lamps recommended by the manufacturer. Different manufacturers may meet the requirement using different lamps. In the interest of energy conservation, lower wattage lamps are preferred.

13.11.2.2. In-pavement Fixtures. Use light fixtures meeting FAA AC 150/5345-46, Type L-852E, class I or II with blue filters. (See figure 13.21.)

13.11.3. Taxiway Guidance Signs. See paragraph 9.3. Use signs meeting the requirements of FAA AC 150/5345-44, Type L-858Y for informational signs, Type L-858L for location signs, and Type L-858R for mandatory signs. The style and the class of sign are dictated by the power source and the operational climate. (See figures 13.22, 13.23 and 13.24.) See FAA Advisory Circular.

13.12. Miscellaneous Lighting Systems:

13.12.1. Airfield Beacons. See paragraph 10.1.

13.12.1.1. Station Rotating Beacon. Use equipment meeting MIL-L-7158. (See figure 13.26.) Use equipment meeting FAA AC 150/5345-12, *Specification for Airport and Heliport Beacon*, Type L-802A only if provided with a double peak in the white portion of the sequence.

Figure 13.21. FAA L-852E, In-pavement, Omni-directional.

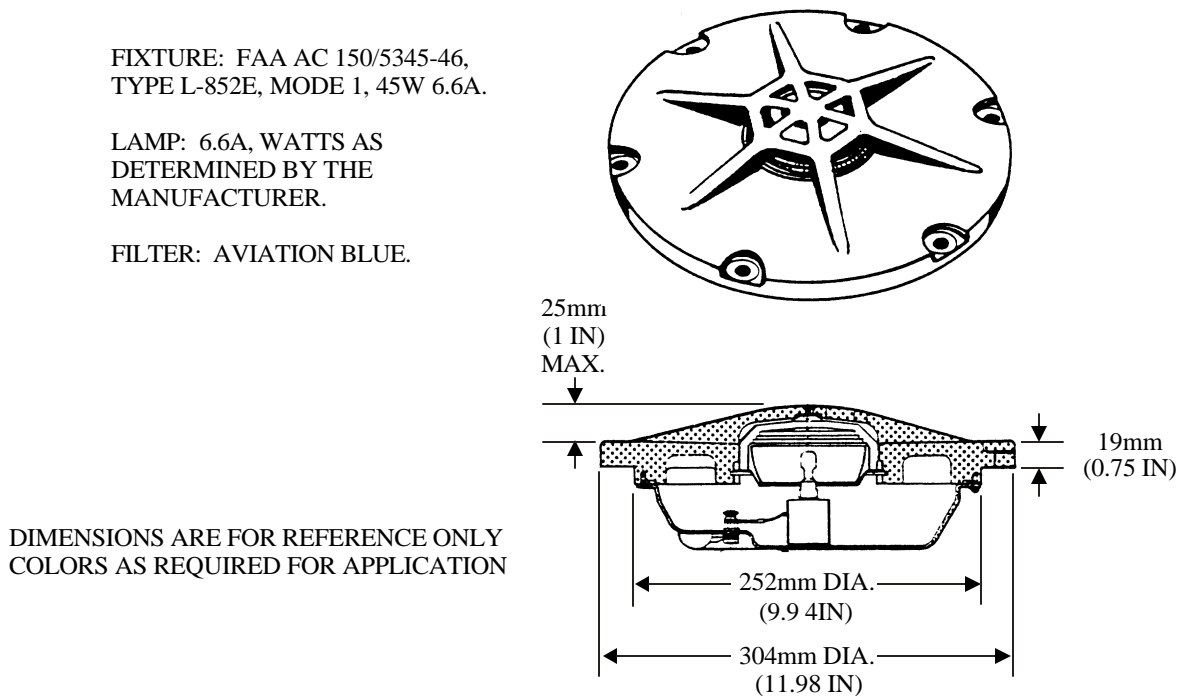


Figure 13.22. FAA L-858Y, Sign, Taxiway, Informational.

SIGNS: INFORMATIONAL
FAA AC 150/5345-44
TYPE L-858Y, SIZE 1, 2 OR 3,
STYLE 2 OR 3, CLASS 1 OR 2,
LEGENDS AS REQUIRED.

LAMPS: RATING AND TYPE
PER MANUFACTURER.

ISOLATION TRANSFORMERS:
6.6/6.6A OR 20/6.6A DEPENDING
ON CIRCUIT, WATTS AND
NUMBER PER MANUFACTURER.

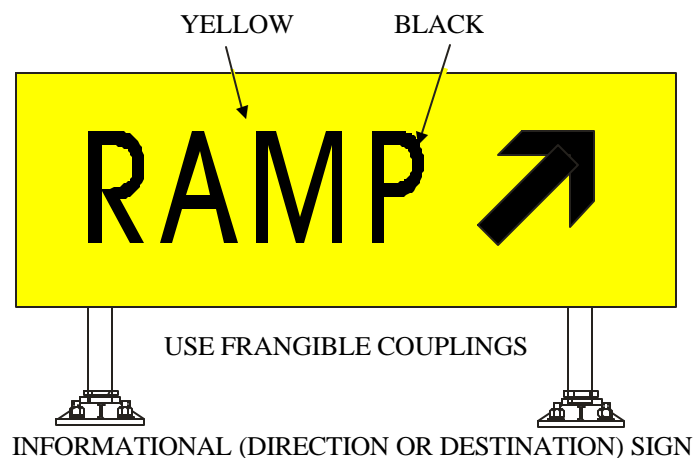


Figure 13.23. FAA L-858R, Sign, Taxiway, Mandatory.

SIGNS: MANDATORY
FAA AC 150/5345-44
TYPE L-858R, SIZE 1, 2 OR 3,
STYLE 2 OR 3, CLASS 1 OR 2,
LEGENDS AS REQUIRED.

LAMPS: RATING AND TYPE
PER MANUFACTURER.

ISOLATION TRANSFORMERS:
6.6/6.6A OR 20/6.6A DEPENDING
ON CIRCUIT, WATTS AND
NUMBER PER MANUFACTURER

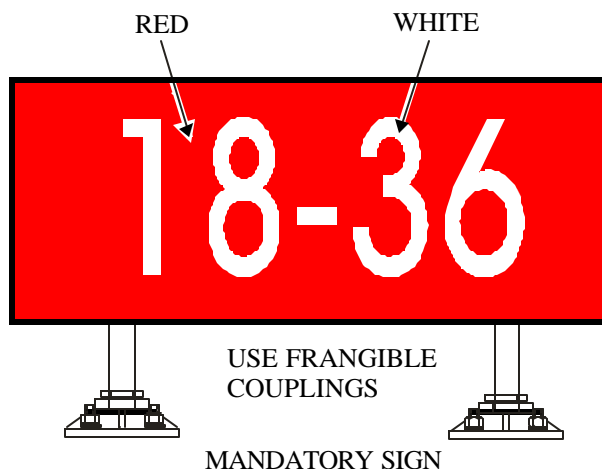


Figure 13.24. FAA L-858L, Sign, Taxiway, Location.

SIGNS: LOCATION
FAA AC 150/5345-44
TYPE L-858L, SIZE 1, 2 OR 3,
STYLE 2 OR 3, CLASS 1 OR 2,
LEGENDS AS REQUIRED.

LAMPS: RATING AND TYPE
PER MANUFACTURER.

ISOLATION TRANSFORMERS:
6.6/6.6A OR 20/6.6A DEPENDING
ON CIRCUIT, WATTS AND
NUMBER PER MANUFACTURER.

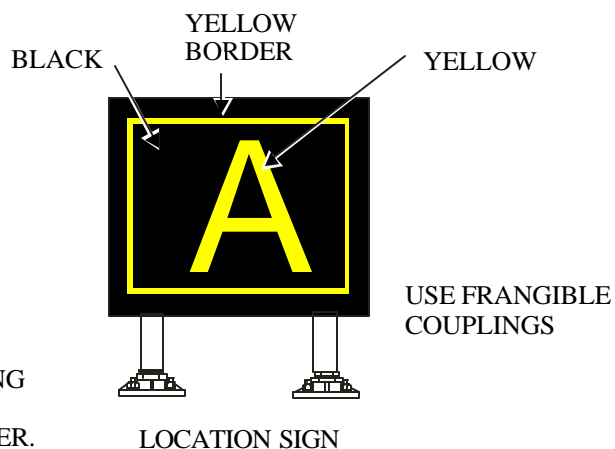


Figure 13.25. FAA L-804, Elevated, Uni-directional Fixture, Runway Guard Lights.

LIGHT: ELEVATED, UNI-DIRECTIONAL
FAA AC 150/5345-46 TYPE L-804
YELLOW, FLASHING

LAMP: TWO 6.6A, WATTS AND
TYPE AS REQUIRED BY MANUFACTURER.

FILTER: AVIATION YELLOW,
203mm (8") DIAMETER, TYPE AS REQUIRED
BY MANUFACTURER.

ISOLATION TRANSFORMER: 6.6/6.6A,
WATTS AS REQUIRED BY MANUFACTURER,
OR FAA AC 150/5345-47
OR
SPECIAL POWER SUPPLY.

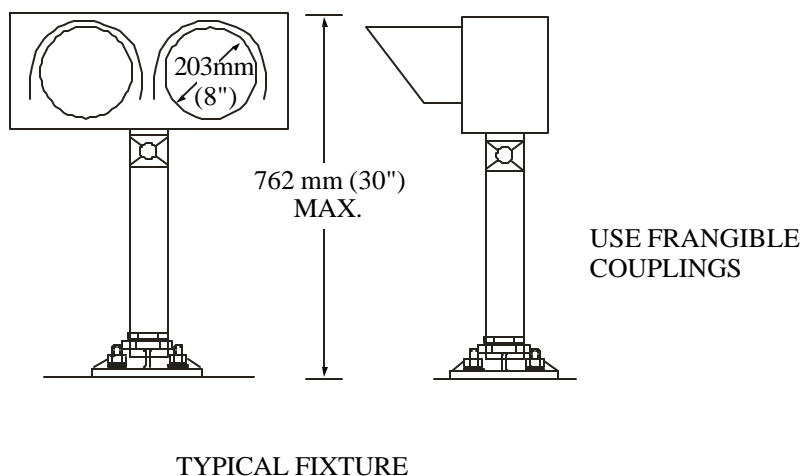
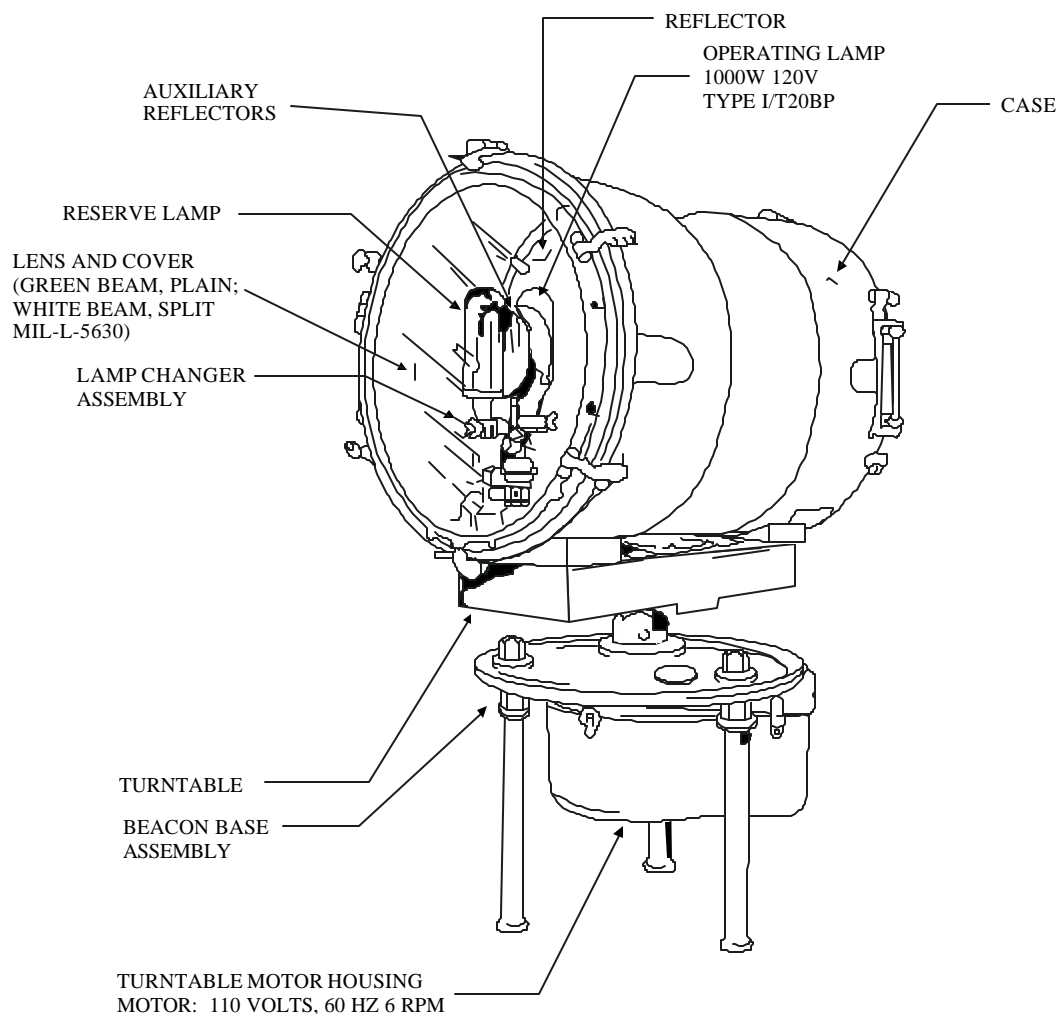


Figure 13.26. MIL-L-7158, Airfield Beacon, Rotating.



13.12.2. Identification Beacon. Use coded beacon equipment meeting MIL-L-6273, *Light, Navigational, Beacon, Obstacle or Code, G-1*. See figure 13.27 or FAA AC 150/5345-12, Type L-803A.

13.12.3. Lighted Wind Indicators (Cones). See paragraph 10.2. Use equipment meeting FAA AC 150/5345-42, Type L-806, size I or Type L-807 size 2. (See figures 13.28 and 13.29.)

13.12.4. Electrical Equipment. The equipment used depends on the power source. If required, use isolation transformers meeting FAA AC 150/5345-47, installed in bases meeting FAA AC 150/5345-42, Type L-867.

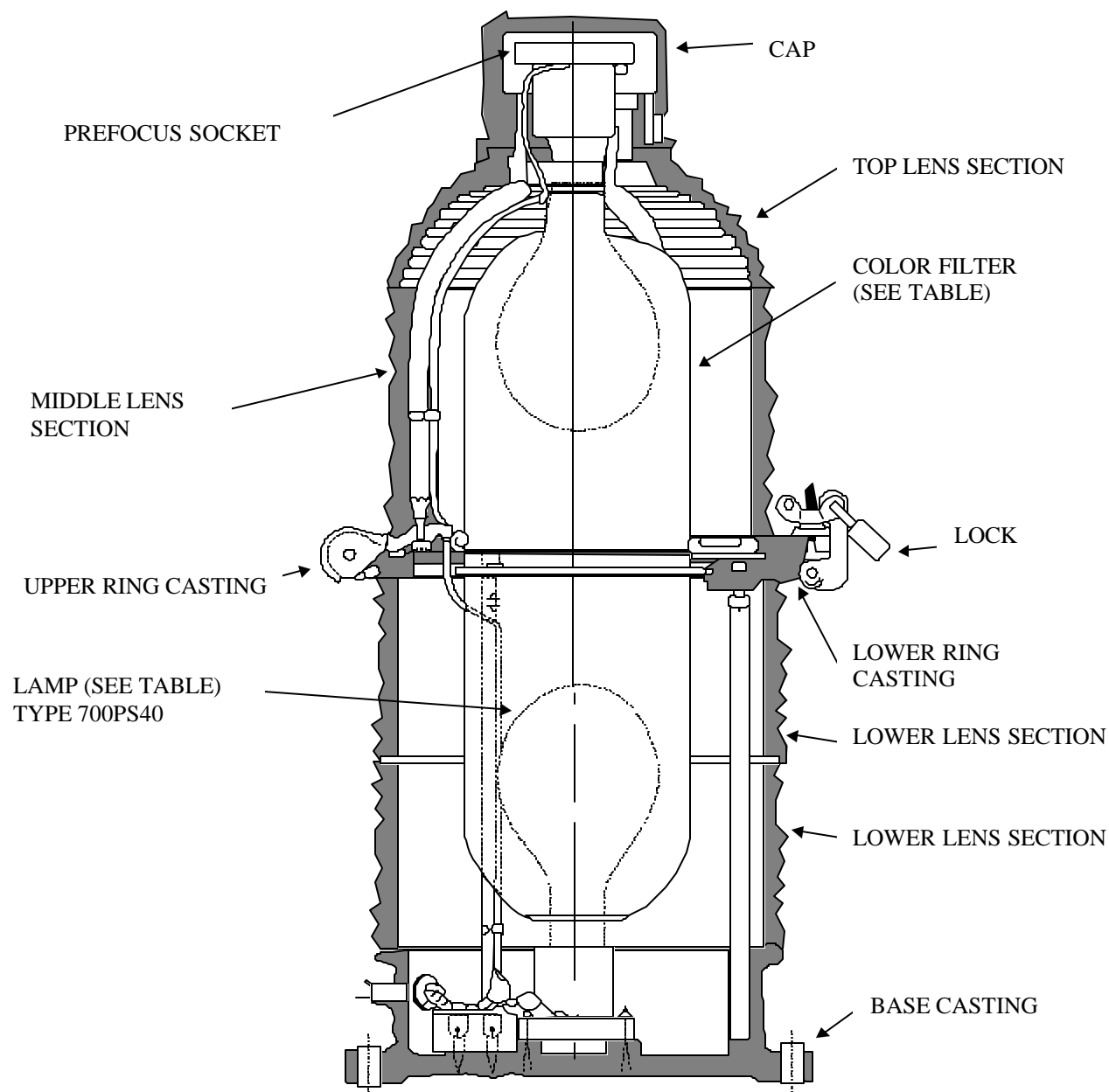
13.13. Obstruction Lighting Equipment. See paragraph 6.1.

13.13.1. Flashing Beacons. Use flashing beacon equipment in red light meeting MIL-L-6273 (see figure 13.27) or FAA AC 150/5345-43, *Specification for Obstruction Lighting Equipment*, Type L-864.

13.13.2. Steady Burning Lights. Use steady burning red lights meeting MIL-L-7830, *Light Assembly, Marker, Aircraft Obstruction*, or FAA AC 150/5345-43, Type L-810. These lights are supplied in single or duplex fixtures. (See figure 13.30.)

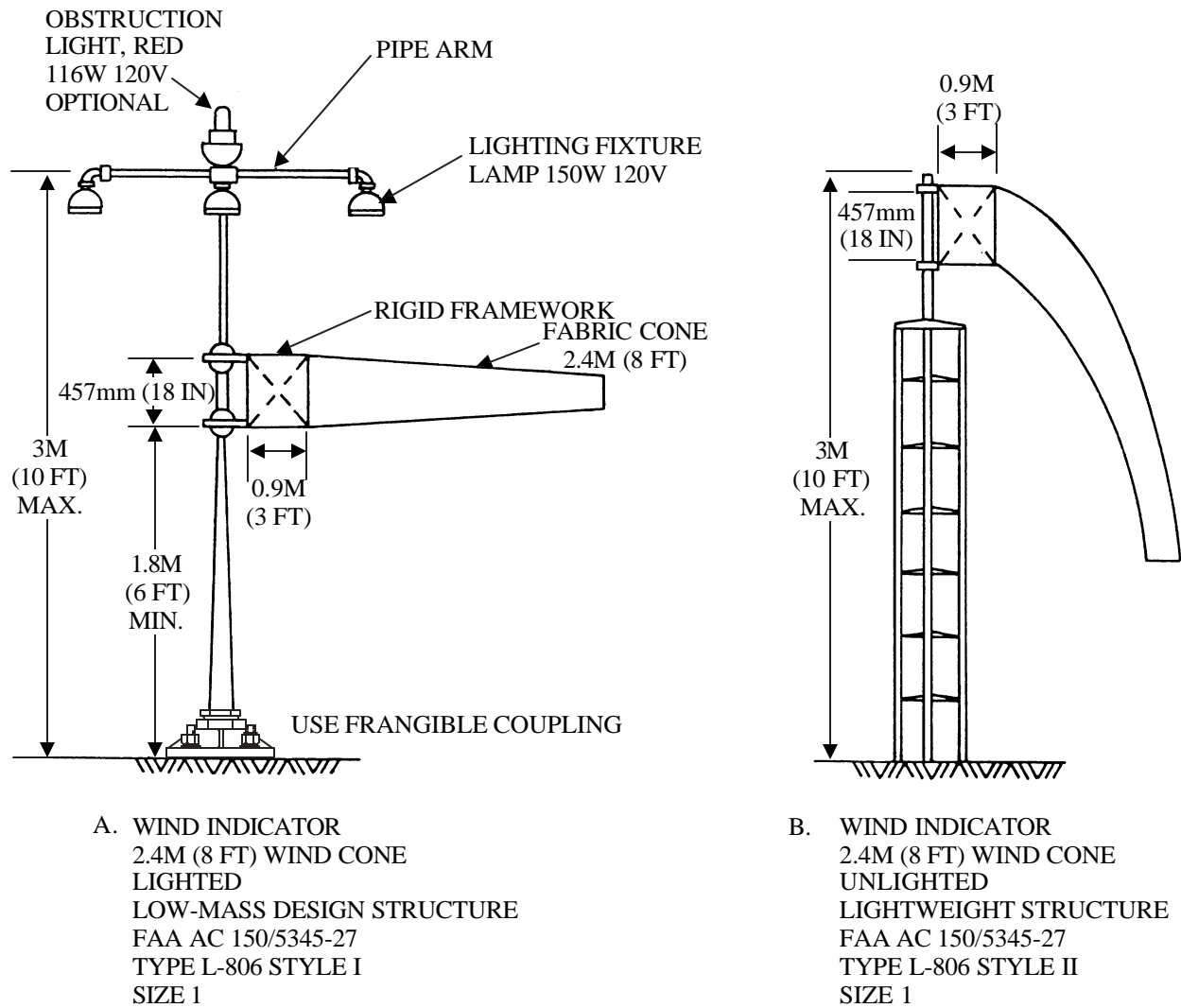
13.13.3. High Intensity Day Marking Light. Use equipment meeting FAA AC 150/5345-43, Type L-856. (See figure 13.31.)

Figure 13.27. MIL-L-6273, G1, Beacon, Code, Flashing.



G-1 BEACON - SPECIFICATION MIL-L-6273					
LAMP			FILTER, MIL-L-6273		
NO. REQD.	WATTS	VOLTS	COLOR	NO. REQD.	USE
2	700	120	RED GREEN	2 2	AS OBSTRUCTION BEACON AS IDENTIFICATION OR CODE BEACON

Figure 13.28. FAA L-806, Windcone, 2.4 Meter (8 Foot).



(DIMENSIONS ARE FOR REFERENCE ONLY)

Figure 13.29. FAA L-807, Windcone, 3.6 Meter (12 Foot).

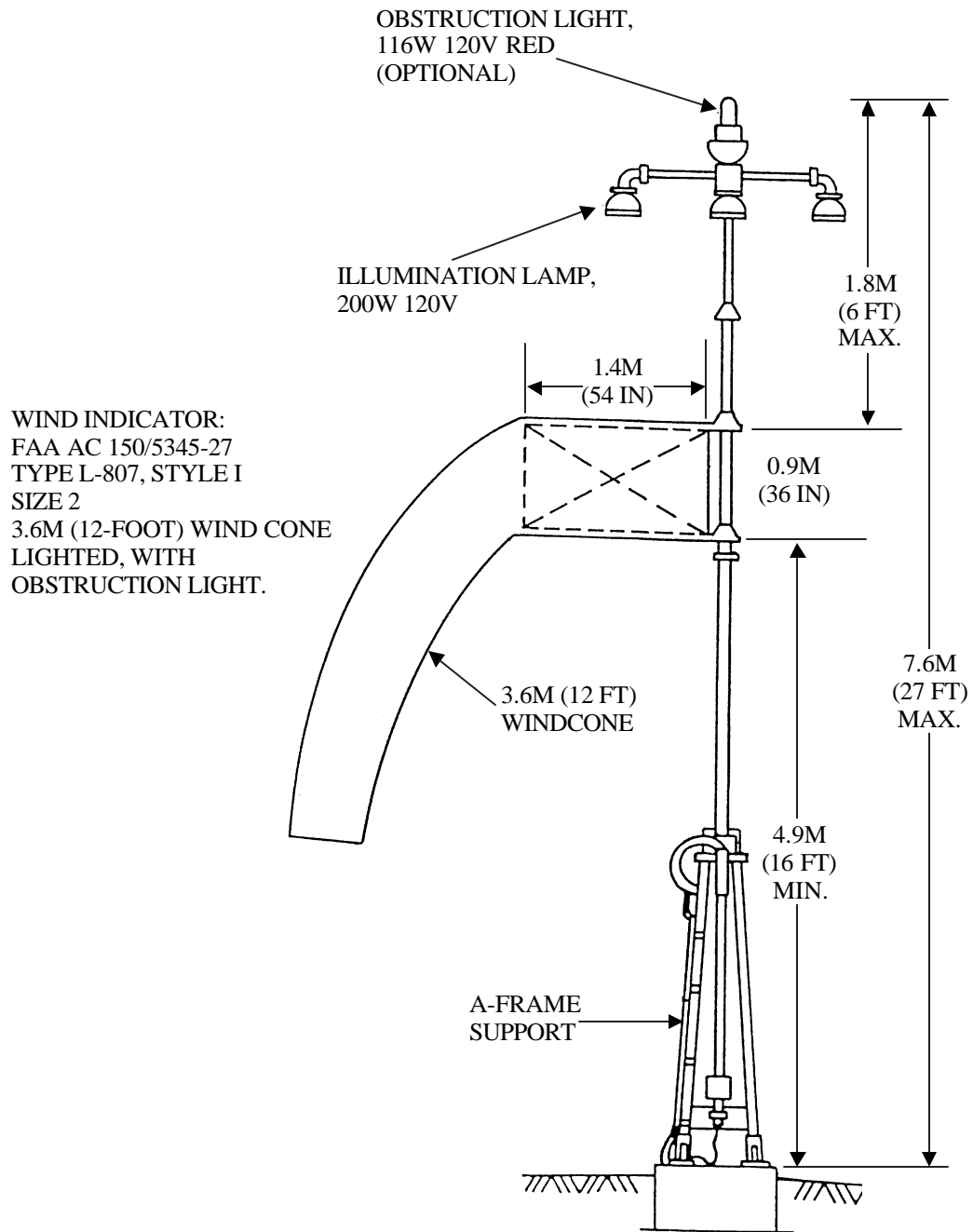
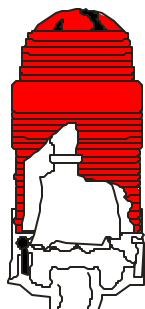
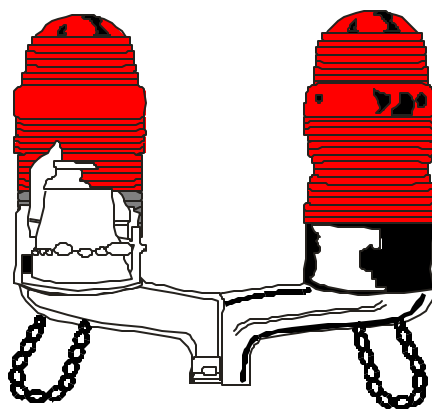


Figure 13.30. FAA L-810, Obstruction Light, Red, Single or Double Globe, Steady Burning.

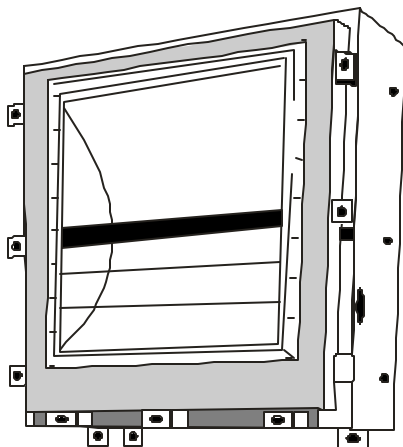


SINGLE STEADY-BURNING LIGHTS,
FAA-AC 150/5345-43 TYPE L-810,
116W 120V TYPE 116A21/TS, OR
125W 120V TYPE 125A21/P LAMP.

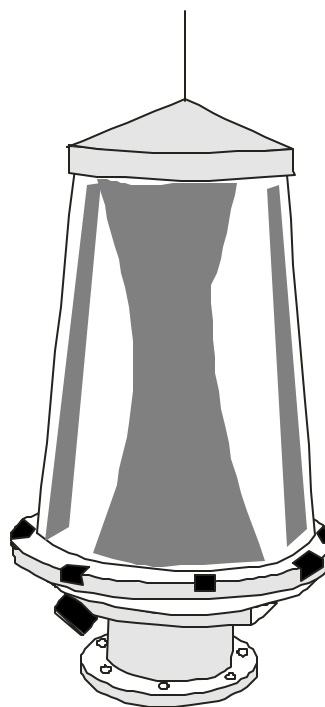


DOUBLE STEADY-BURNING LIGHTS
FAA AC 150/5345-43 TYPE L-810,
116W 120V TYPE 116A21/TS, OR
125W 120V TYPE 125A21/P LAMP

Figure 13.31. FAA L-856, 857, 865, 866, Obstruction Lights, Flashing, High or Medium Intensity.



HIGH-INTENSITY WHITE
OBSTRUCTION LIGHT,
FAA AC 150/5345-43,
TYPE L-856.



MEDIUM-INTENSITY WHITE
OBSTRUCTION LIGHT,
FAA AC 150/5345-43
TYPE L865, L866

13.14. Helipad Lighting Equipment. See paragraph 7.1.

13.14.1. Elevated Perimeter, Landing Direction and Approach Direction Lights. Use fixtures meeting FAA AC 150/5345-46, Type L-861. (See figure 13.12.) Use yellow filters except in approach direction lights that are white.

13.14.2. In-pavement Perimeter, Landing Direction and Approach Direction Lights. Use fixtures meeting FAA AC 150/5345-46, Type L-852E. (See figure 13.21.) Use yellow filters except in approach direction lights that are white.

13.14.3. Heliport Beacons. Use beacon equipment meeting FAA AC 150/5345-12, Type L-801H. (See figure 13.32.)

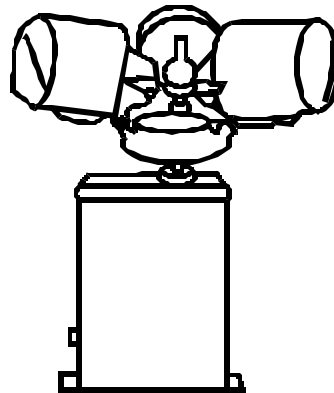
Figure 13.32. FAA L-801H, Beacon, Rotating, Helipad.

HELIPORT BEACON:
FAAAC 150/5345-12, TYPE L-801H
CLASS 2

LAMPS: 3, RATING AND TYPE AS
DETERMINED BY THE MANUFACTURER

TRANSFORMER: VOLTAGE DISTRIBUTION,
COMMERCIAL, RATING AS DETERMINED
BY THE MANUFACTURER

COLORS: DOUBLE-PEAKED WHITE,
GREEN, AND YELLOW



13.14.4. Helipad Floodlighting. No specific equipment has been identified to meet the standard.

13.14.5. Helipad Wind Indicators (Cones). Use indicator meeting FAA AC 150/5345-27, type L-806. (See figure 13.28.)

13.14.6. Chase Helipad Approach Path Indicator (CHAPI). This system is a modified PAPI system with a green glide path indicator added (usually 2 degrees) use equipment meeting FAA AC 150/5345-27.

13.15. Specification Availability. Various FAA specifications are cited in this document in the text and figures. The following is a title list of those that are cited.

13.15.1. FAA Advisory Circulars. The FAA has available an Advisory Circular Checklist AC OO-2.X, that lists all of the documents, and how to obtain them. The FAA may be contacted at 1-800-FAA-SURE, or (202) 267-9532, Fax (202)512-2250. The following FAA advisory circulars, shown in table 13.1, may be obtained from the US Department of Transportation, Distribution Requirements Section, M-483.1, Washington, DC 20590. Request latest edition.

Table 13.1. List of FAA Advisory Circulars.

DOC. NO.	TITLE
AC 70/7460-1	Obstruction Marking and Lighting.
AC 120/57	Surface Movement Guidance and Control System.

DOC. NO.	TITLE
AC 150/5340-1	Standards for Airport Markings.
AC 150/5340-24	Runway and Taxiway Edge Light Systems.
AC 150/5340-26	Maintenance of Airport Visual Aid Facilities.
AC 150/5340-28	Low Visibility Taxiway Lighting Systems
AC 150/5345-3	Specification for L-821 Panels for Control of Airport Lighting.
AC 150/5345-5	Circuit Selector Switch.
AC 150/5345-7	Specification for L-824 Underground Electrical Cable for Airport Lighting Circuits.
AC 150/5345-10	Specification for Constant Current Regulators and Monitors.
AC 150/5345-12	Specification for Airport and Heliport Beacon.
AC 150/5345-13	Specification for L-841 Auxiliary Relay Cabinet Assembly for Pilot Control of Airport Lighting Circuits.
AC 150/5345-26	Specification for L-823 Plug and Receptacle, Cable Connectors.
AC 150/5345-27	Specification for Wind Cone Assemblies.
AC 150/5345-28	Precision Approach Path Indicators (PAPI) Systems.
AC 150/5345-42	Specification for Airport Light Bases, Transformer Housings, Junction Boxes and Accessories.
AC 150/5345-43	Specification for Obstruction Lighting Equipment.
AC 150/5345-44	Specification for Taxiway and Runway Signs.
AC 150/5345-45	Lightweight Approach Light Structure.
AC 150/5345-46	Specification for Runway and Taxiway Light Fixtures.
AC 150/5345-47	Isolation Transformers for Airport Lighting Systems.
AC 150/5345-49	Specification L-854, Radio Control Equipment.
AC 150/5345-50	Specification for Portable Runway Lights.
AC 150/5345-51	Specification for Discharge-type Flasher Equipment.
AC 150/5345-53	Airfield Lighting Equipment Certification Program.

13.15.2. Standards, Specifications, and Drawings. The following standards, specifications, and drawings, shown in table 13.2, may be obtained from the Federal Aviation Administration, Program Engineering and Maintenance Service, Washington, DC 20591.

Table 13.2. List of Standards, Specifications, and Drawings.

DOC. NO.	TITLE
FAA-E-910	Structural Steel.
FAA-E-982	PAR 56 Lamp Holder.
FAA-E-1315	Light Base and Transformer Housing.

DOC. NO.	TITLE
FAA-E-2159	Runway End Identifier Lighting System (REIL).
FAA-E-2325	Medium Intensity Approach Light System with Alignment Indicator Lights.
FAA-E-2491	Approach Light, Semi-flush, Steady Burning.
FAA-E-2628	Sequenced Flashing Lighting System Elevated and Semi-flush with Dimming and Monitoring.
FAA-E-2651	Omni Directional Approach Lighting System (ODALS).
FAA-E-2689	Dual Mode High Intensity Approach Lighting System (ALSF-2/SSALR).
FAA-E-2702	Low Impact Resistant Structures.
FAA-E-2756	Four Box PAPI.
FAA Drawing C-6046	Frangible Coupling Type I and Type IA, Details.
FAA Drawing D-6076	ALSF-2 Approach Lighting System 6'-0" to 128'-0" Low Impact Resistant (LIR) Structures.
FAA Drawing D-6155	ALSF-2, 6' to 128' and MALS, 40' to 128' LIR Structures.
MIL-L-7158	Light, Beacon, Rotating, 24-inch

13.16. Considerations For Additional Equipment Requirements. This paragraph provides characteristics and features for some equipment or subsystems beyond the minimum required by FAA standards. These have been identified as improving system performance, or in the case of computerized control system, provide criteria for equipment not yet covered by FAA standards but for which components are commercially available and often used for newer installations.

13.16.1. Constant Current Regulator. The following features and characteristics for L-828 and L-829 constant current regulators typically result in a better and more safe installation.

13.16.1.1. Display of line voltage, line current, and load voltage.

13.16.1.2. Built-in meter monitoring output current, true RMS, with at least $\pm 3\%$ accuracy.

13.16.1.3. Remote back indication for the individual brightness steps (providing positive signal to tower that CCR is on the selected step).

13.16.1.4. The capacity of the regulator must be rated in nominal KVA (kilovolt-amperes) output (instead of KW). KVA rating is recommended in order to better correspond with field circuit loads and current steps. When the load is almost completely resistive, the KW rating may be used as an approximation.

13.16.1.5. Size the regulators rated 10KW and above to match connected load with 50% to 100% of rated load. Taps on regulators are recommended to help match connected load with rated load and provide a means to accommodate load changes in the system.

13.16.1.5.1. For resistive loads: In the range of 50% to 100% of the nominal load at rated input voltage, with output current at 100%, the efficiency and power factor should not be less than the values specified by FAA AC 150/5345-10. [Efficiency not less than 80%; power factor not less than 0.90.]

13.15.1.5.2. For reactive loading: The regulator is required to maintain the current within the permitted tolerance for all current steps when the load is connected via isolation transformers and the secondary of 30% of these transformers become open-circuited. The load before opening the isolation transformers may be of any value between 50% and 100% of the nominal load.

13.16.1.6. Harmonics: The regulator should generate minimum harmonics on the input power lines. Third harmonics should be reduced as much as possible, sufficient to meet IEEE standards (IEEE 519-1992, *Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems*, Chapter 10). [From Chapter 10: “It would be ideal if it were possible to control harmonics to such an extent that harmonic effects caused by connections of harmonic-producing loads were nil at every point in the entire system encompassing the consumer’s own circuit.”]

13.16.1.7. For compatibility of the regulator with the equipment powered by the regulator (such as signs), the manufacturer should be required to supply with the qualification documents oscilloscope photo/printouts of output current and voltage waveforms at nominal line voltage for all brightness steps, in short circuit, at half load, and at full load. The half-load and full-load waveforms should be taken with pure resistive loading, then repeated with 30% isolation transformers open circuit. The output waveforms provide a means for manufacturers of equipment to be connected to ensure compatibility with approved regulators.

13.16.1.8. Isolation of high voltage equipment (1000V or greater) from the low voltage equipment, either by construction when in the same location, or by separation within the regulator.

13.16.1.9. The doors for access to high voltage components within the regulator should be equipped with safety door interlocks that de-energize the regulator before access is gained, and prevent energizing with the door opened. The door should be fitted with an appropriate label, such as: DANGER HIGH VOLTAGE, DE-ENERGIZE SWITCH BEFORE OPENING THIS DOOR.

13.16.1.10. Regulator cabinets should be designed for easy movement to facilitate installation (i.e., rollers or lifting rings) and should also have an additional ground terminal to connect cable shielding.

13.16.1.11. Readable wiring diagram, indicating all customer connection points, permanently mounted unobstructed in regulator.

13.16.1.12. Alarms, to be indicated on front of the unit:

13.16.1.12.1. Indicator that an open-circuit trip-out has occurred.

13.16.1.12.2. Indicator that an over current trip-out has occurred.

13.16.1.12.3. Warning indicator that the selected current step is not within $\pm 3\%$ of the set current values.

13.16.1.13. Nameplate securely attached to the exterior of the regulator. If on a readily removable surface (such as a cover) the serial number should be duplicated elsewhere on the regulator in a conspicuous place. The nameplate must contain as a minimum the following:

Constant Current Regulator

Manufacturer’s Name and Part Number:

Number of Current Steps: _____

Input : Volts _____ Hertz _____

Input Current at Full Load: _____

Remote Control Voltage: _____ Volts DC (or Volts AC)

Output: _____ kVA and KW at 6.6 (or 20) Amperes

Maximum Full Load Output Voltage: _____ Volts

Serial Number:

13.16.2. S-1 Plug Cutout. Comply with FAA AC 150/5340-4, figures 13 and 14. Install in NEMA 1 enclosure.

13.16.3. Circuit Selector Switch. Comply with FAA AC 150/5345-5, L-847. For use when multiple circuits are connected to a single constant current regulator, or for preventing interconnecting two regulators

on some installations that provide switching to a spare regulator. Input and control voltages must be selected. Options typically include status indication and cabinet type.

13.16.4. Isolation Transformer. The following characteristics for L-830 (60 Hz) and L-831 (50 Hz) isolation transformers represent current products and improve quality over the minimum FAA standards:

13.16.4.1. Minimum thickness of encapsulation: 6.5 mm.

13.16.4.2. Minimum power factor: 0.95 (at nominal resistive load and rated primary current).

13.16.4.3. Maximum dielectric strength (hot and cold): 2 microamperes, with primary tested at 15 KVdc and secondary tested at 5 KVdc.

13.16.4.4. All internal connections to be permanent (i.e., high-pressure crimping or high-pressure soldering).

13.16.5. Runway and Taxiway Guidance Signs. The following are recommended for L-858 signs to limit impact on upstream equipment, and provide performance and safety benefits.

13.16.5.1 Maximum volt-ampere (VA), as measured at input to isolation transformer (if no limits are set for VA, many signs on a circuit can have significant effect on upstream equipment):

1 module, or 1 - 1.5 meter (3 - 5-foot) length -	150 VA
2 modules, or 1.5- 2 meter (5 - 7-foot) length -	250 VA
3 modules, or 2.5 - 3.5 meter (8 - 12-foot) length -	300 VA
4 modules, or 4+ meter (13+) length -	400 VA

13.16.5.2. Power Factor - minimum 0.85 at all intensity steps.

13.16.5.3. External disconnect switch that shorts secondary of isolation transformer when switch is turned off.

13.16.5.4. Tethers - minimum 2 per sign.

13.16.5.5. Average luminance:

13.16.5.5.1. Types L-858Y, L & R Sign, white or yellow legend or background: 34-100 cd/m² (10-30 footlamberts), with 55-100 cd/m² (16-30 footlamberts) at two highest intensity steps. The ratio of any two measurements on any part of the sign (yellow or white portion) must not be greater than 6:1.

13.16.5.5.2. Type L-858R Sign (mandatory): Ratio between message (white) and background (red) will not be more than 10:1 or less than 5:1

13.16.5.5.3. Type L-858B Sign (RDM): 100-300 cd/m² (30-88 footlamberts) (white).

13.16.5.6. Compatible with all L-828/L-829 regulators. Sign manufacturer must assure that pulsed demand of sign will synchronize with pulsed output of regulator. Unacceptable synchronization may be evidenced by sign flickering, abnormal noises from regulator, failure to stabilize by 1 second after change of intensity steps, or spikes on the output current or voltage waveforms. The sign should not require field adjustment for proper operation following changes in circuit loading or regulator type. The sign manufacturer should analyze the regulator output waveforms to verify that signs will perform satisfactorily and without adversely impacting the regulator, at all load conditions from no- to full-load capacity.

13.16.5.7. Operation. Operation to be at any incoming current value of a series lighting circuit. Rated operating lamp life: Minimum 2,500 hours (when operated at highest intensity step).

13.16.6. Computerized Control Systems. Modern control/monitoring systems for Visual Air Navigation facilities are usually based on the use of a Programmable Logic Controller (PLC) or a PC computer. These may have touch screen or track ball user interface, and may use fiber optic cable in place of the traditional multi-conductor copper control cables to link the various stations. Commercial standards are available for some components of such systems; however, standards are not yet established for integrated systems. Often, the computerized system installed is based on one specific manufacturer's equipment, which locks the facility into one manufacturer for servicing and parts, often costly to the facility. Also, new systems often have a

response delay from control action by the tower, compared with the instant response of the traditional relay type systems, resulting in a short moment of user uncertainty if his selection has been carried through. In selecting and specifying a computerized control system, technology continues to evolve, the characteristics presented in Table 13.3 should be considered. Further discussion of this type system is presented in Chapter 15.

13.16.6.1. General function for Control and Monitoring:

13.16.6.1.1. Minimum operating capabilities: determination of the functional status of the system; identification of the intensity level at which each circuit is operating.

13.16.6.1.2. Suitable for complexity and particular needs of airfield, and adaptable to changes (modular).

13.16.6.1.3. Redundancy of equipment or elements crucial for safety.

13.16.6.1.4. High degree of reliability and availability.

13.16.6.1.5. Capable of data exchange with related systems.

13.16.6.1.6. Provide an intuitive operator interface. Include the capability of monitoring and controlling all visual navigation aids controllable by a conventional control system. Identify alarm conditions.

13.16.6.2. Basic Peripherals and Features:

13.16.6.2.1. User interface (controller, maintenance staff, other), user-friendly with secure transfer and relevant status information for each station. Typical installations use touch screen or track-ball, based on local preference.

13.16.6.2.2. Display: Should show continuous visual presentation of the true status of the several subsystems being controlled/monitored. Graphic display should depict a representation of the airfield, showing the configuration and location of the various lighting circuits. The display should indicate the status (i.e., ON/OFF or step), circuit/system identification, as well as condition of each system or subsystem. The colors selected should correlate with the lighting system being represented.

13.16.6.2.3. Event recording devices (storage, printer) for time and sequence of alarms and status information. In the event of failure, the system must ensure that the status of the subsystem will not change automatically to a dangerous or undesirable condition. For most airfield lighting systems, the actual intensity level selected at the time of a failure should be maintained in order to preserve the operational state. Systems which protect safety related zones on the airfield, such as a runway, should be switched on or off, as appropriate for the operational requirements.

13.16.6.2.4. Interface to regulators and other units for control and status indications, and for monitoring.

13.16.6.2.5. Optional other interfaces (e.g., field sensors, meteorological systems, or SMGCS).

13.16.6.3. Power Considerations:

13.16.6.3.1. If secondary power supply for the airfield systems is provided, the control/monitoring system should be switched to the secondary supply along with lighting systems in the event of a failure or initiated transfer. During switch-over, the control/monitoring system must maintain any relevant information and commands.

13.16.6.3.2. If control/monitoring system, or any subsystems, are not tolerant of power interruption, all sensitive components should be furnished with their own uninterruptible power supply (UPS). The capacity of the UPS should ensure operation for a period of at least 20 times the maximum switch-over time to the secondary power supply.

13.16.6.4. System Response Time. The response time of a computerized control system may vary. It is therefore recommended that minimum response times be considered when selecting a system. The response times in table 13.3 are recommended in specifying a computerized airfield ground lighting (AGL) control system.

Table 13.3. AGL Control System Response Times.

Time Characteristic	Response Time (seconds)
From command input until acceptance or rejection	< 0.5
From command input until control signal output to regulator or other controlled unit	< 1.0
For system to indicate that a control device has received the control signal	< 2.0
Back indication to tower display of regulator initiation	< 1.0
Switch-over time to redundant components in event of system faults (no command execution during this time)	< 0.5
Automatic detection of failed units and communication lines of the monitoring system	< 10

13.16.6.5. Operations and Maintenance Log. Log all operationally significant events. The log may be compiled manually or by electronic means and should be retained for at least 30 days. The ability to display or print out periodic or summary compilations of important operational and failure events is recommended.

13.16.6.6. Product Considerations.

13.16.6.6.1. Hardware. Maximize off-the-shelf components. Compliant with industry standards for each component.

13.16.6.6.2. Monitor. Minimum 432 millimeter (17-inch), flat screen.

13.16.6.6.3. Software. Common operating system (e.g., Windows or UNIX). Tailored packaged graphics program, easily modified.

Chapter 14

AIR FACILITY EQUIPMENT INSPECTION AND TESTING

14.1. Contractual Acceptance Tests. Test and inspect during construction and before accepting and placing a new system into service to ensure the system is operating properly and has been constructed as designed. The government will conduct a commissioning flight inspection on all light systems covered by AFMAN 11-225 (I). Establish responsibility for any deficiencies found and complete corrective action before releasing the construction contractor. This chapter applies to inspection and testing during construction and the contractual acceptance tests of new installations. Include the applicable contractual test procedures in the contract specifications. If the installation is not accomplished by contract, perform the tests before making the system operational.

14.1.1. Electrical Safety. Most airfield lighting circuits and power supply equipment operate at high voltages. Qualified personnel, who are familiar with high voltage electrical equipment and the safety precautions that

must be observed, must perform the tests defined in this chapter. The following are general safety precautions that apply to all work in or around electrical equipment, and specifically for series lighting circuits. Understand and apply these precautions during all phases of operation and maintenance, whether working in the lighting vault or on the field circuits. Additional safety information can be found in: AFMAN 32-1185, *Electrical Worker Safety*, and EM 385-1-1, *Safety and Health Requirements Manual*; FAA AC 150/5340-26, *Maintenance of Airport Visual Aid Facilities*; MIL-HDBK 1023/4, *Maintenance of Visual Air Navigation Facilities*; and MIL-HDBK 1023/5, *Maintenance Standards for Visual Air Navigation Facilities*.

14.1.1.1. Two Basic Rules:

14.1.1.1.1. Work should never be performed on energized electrical conductors or equipment, except for measuring voltage or current. Lock out equipment if it is not easily visible from the work site.

14.1.1.1.2. Always assume that power is on until the true condition is determined.

14.1.1.2. Safety Practices:

14.1.1.2.1. All commercial test equipment should be UL approved.

14.1.1.2.2. Prior to beginning work on airport lighting circuits, coordinate work schedule with Tower. Obtain authorization for local control.

14.1.1.2.3. If work is on high voltage circuit (480V or higher for purposes of this document), at least two electricians should be present, one having thorough knowledge of high voltage circuits. Observer should: keep other personnel not involved in work clear of equipment, be familiar with power disconnects and immediately disconnect power source in case of emergency, be qualified in first aid, and observe work to detect and warn against unsafe practices.

14.1.1.3. Personal Safety Precautions:

14.1.1.3.1. Know location of main power disconnect devices.

14.1.1.3.2. Know how to summon medical aid.

14.1.1.3.3. De-energize circuits using proper procedures.

14.1.1.3.4. Verify that voltage is off by using a voltmeter on the component after opening the power switch.

14.1.1.3.5. Insulate feet by standing on a dry rubber mat. Remember that contact with the grounded equipment cabinet could nullify this protection.

14.1.1.3.6. Stay clear of terminals, leads, or components that carry voltages of any magnitude. Avoid contact with components that are grounded, including frame.

14.1.1.3.7. Be certain there is no power applied to a circuit when making continuity or resistance check (meter will be damaged).

14.1.1.3.8. Ensure that both the test equipment and the equipment under test are properly grounded.

14.1.1.3.9. Do not wear jewelry, wristwatches, or rings while working with electrical equipment.

14.1.1.3.10. Keep clothing, hands, and feet dry if at all possible.

14.1.1.3.11. Use the correct tool for doing the job.

14.1.1.3.12. Never use toxic or flammable solvents for cleaning purposes.

14.1.1.3.13. Where air pressure is required for cleaning, use low-pressure (30 psi or less) air source. Use eye protection with compressed air.

14.1.1.3.14. Goggles and safety shoes should be worn when around high voltage.

14.1.1.3.15. Never compromise safety.

14.1.1.4. Common Causes of Accidents:

14.1.1.4.1. Working on equipment without adequate coordination with user.

- 14.1.1.4.2. Working on equipment without sufficient experience on that equipment.
- 14.1.1.4.3. Failure to follow instructions in equipment manuals.
- 14.1.1.4.4. Failure to follow safety precautions.
- 14.1.1.4.5. Using unsafe equipment.
- 14.1.1.4.6. Failure to use safety devices.
- 14.1.1.4.7. Working at unsafe speeds.
- 14.1.1.4.8. Poor housekeeping of work areas.

14.2. Guarantee Period. Each installation contract will include a guarantee or warranty clause. It must specify a period of at least one year, after acceptance, during which the installation contractor is responsible for repairing and replacing, without charge, all cable or equipment failures resulting from poor work performance or defective materials and equipment. System failure can occur within months after installation due to faulty installation practices.

14.3. Visual Examination. Thorough visual inspections are the most important of all inspection and test procedures. Visual inspections must be made frequently during installation, at completion of installation, and before energizing the circuits. A careful visual inspection will reveal defects that should be corrected before acceptance tests and energizing. Serious damage may occur if defects are subjected to electrical tests or energizing. Visual inspections will include: correctness of external connections, good workmanship, cleanliness, safety hazards, and specific requirements for individual items. All equipment manufactured under specifications pass strict factory tests before shipment, but it must be inspected for shipping damage immediately upon receipt.

14.3.1. Visual Inspection Checklists. Tables 14.1 through 14.8 provide checklists that can be used for visual inspection, during installation and as part of acceptance procedures, for various components and subsystems. Similar lists are recommended for items not included in the tables below.

Table 14.1. Checklist for High Intensity Runway Lighting (Elevated, Base Mounted).

Bases

- ___ 1. Are transformer housings of the correct type, size and material?
- ___ 2. Are transformer bases installed level, to proper grade, and with proper bolt pattern orientation?
[Tops of transformer housings should be slightly above surrounding grade in non-paved areas, or flush with grade in paved areas (to keep water away from covers). There should be smooth transition between concrete envelope and surrounding grade. Allowances must be made for spacer rings or pavement rings where used.]
- ___ 3. Are transformer base cover gaskets properly installed, with all bolts properly torqued? [Use only stainless steel bolts; do not reuse shipping bolts unless so intended by the manufacturer.]

Lights

- ___ 4. Are all equipment and materials new, and as specified? Are lamps and isolation transformers of proper wattage? [Items covered by the FAA L-800 series should be listed in the FAA AC 150/5345-53.]
- ___ 5. Are all light locations in accordance with the plans?
- ___ 6. Are the correct filters installed and light lenses properly oriented for runway edge lights? For threshold/end lights?
- ___ 7. Are the light lines at proper distance from the pavement or defined edge, in straight line within tolerance?
- ___ 8. Is the height of light fixtures in accordance with the plans, and breakable couplings properly installed?
- ___ 9. Are all lights plumb and are their heads tight and level? Are bi-directional lights properly oriented relative to the runway? [Bi-directional lights have toe-in and must be oriented properly relative to runway.]

Cables

- ___ 10. Are L-823 connectors of proper size for the cable, and are field attached connectors applied properly per details (taping/heat shrink)?
- ___ 11. Are all L-823 Type II two conductor secondary connectors Class A (factory molded)?
- ___ 12. Has grounding of light base been provided in accordance with the plans? Are ground rods installed to at least minimum depth below grade and within maximum spacing?
- ___ 13. Is counterpoise properly separated from light bases and base grounding provisions?
[The counterpoise/grounding policy may not be the same at each air base. Ensure compliance with plans.]

System

- ___ 14. Are lights labeled in accordance with approved numbering scheme, with proper tag and size of numerals? Are edge light numbering tags facing the pavements?
- ___ 15. Are all new lights operational? Is there any visual evidence of dimming?

Table 14.2. Checklist for In-pavement Lights.

<u>Progress Inspection</u>	
_____	1. Are all equipment and materials new, and as specified? Are transformer housings of the correct type, size and material? Are lamps of proper wattage? [Items covered by the FAA L-800 series should be listed in the FAA AC 150/5345-53.]
_____	2. Are the recesses for inset lights or light bases being located within the allowable dimensional tolerances?
_____	3. Is the coring and sawing equipment capable of producing acceptable recesses and kerfs?
_____	4. Is the recess diameter and depth in accordance with the plans? Is the width and depth of the saw kerfs in accordance with contract requirements?
_____	6. Are the inset light base jigs capable of accurate receptacle/light base alignment and of holding the receptacle/light base firmly during pouring and curing of concrete?
_____	7. Are the light bases being aligned and leveled within the allowable tolerances, and receptacles/light bases being installed at proper elevation? [Tops of transformer housings must be proper depth below grade, depending on type of fixture and allowance for spacers and pavement ring, as required by plans and manufacturer's instructions.]
_____	8. If epoxy is required: <ul style="list-style-type: none"> - Has the epoxy manufacturer supplied adequate and clear instructions for mixing, handling, and installation of the material, and are the instructions being followed? - Is material being machine mixed, and are sample tests of the epoxy being made? - Are the temperatures (air and pavement) within allowable tolerances for the type of epoxy being used?
_____	9. Are the ends of all wires sealed when they are not being immediately connected?
_____	10. Are the L-823 connectors of proper size and do they properly fit the cable?
_____	11. Has taping/heat shrink for field attached connectors been applied properly, per details?
_____	12. Are the plywood or steel covers kept on the light bases until just before installation of the light fixture, in order to prevent entry of any foreign matter?
_____	13. Are the receptacles/light bases cleaned and dried before installation of the light fixtures?
_____	14. Are all bolts of stainless steel and torqued per manufacturer's instructions?
_____	15. Has grounding of light base been provided in accordance with the plans?
_____	16. Where secondary wires are installed in conduit which is epoxy sealed in saw kerfs: <ul style="list-style-type: none"> _____ a. Is the width and depth of the saw kerfs as required by plans? _____ b. Are the recesses and saw kerfs properly sand blasted, cleaned, and dried just before installation and sealing of the conduit or wire?

Table 14.2. Checklist for In-pavement Lights (Cont.).

- _____ c. Is the conduit or wire properly secured in the saw kerf before adding the epoxy?
[acceptable wedges at proper spacing.]
- _____ d. If required, is flexible conduit used to terminate rigid conduit at the base?
- _____ e. Are expansion joints installed in conduit where required?
- _____ f. Are the secondary wires before sealing and connecting to transformers being tested for insulation resistance and continuity, and are the results acceptable and being recorded?

Final Inspection

- _____ 1. Are all the lenses clean and dry?
- _____ 2. Are colored filters installed in accordance with the plans?
- _____ 3. Are the L-823 connectors of proper size and do they properly fit the cable?
- _____ 4. Has taping/heat shrink for field attached connectors been applied properly, per details?
- _____ 5. Are base spacers, rings, gaskets installed for correct elevation relative to pavement, and are bolts securing fixture stainless steel and properly torqued?
- _____ 6. Has all excess epoxy been removed so that no epoxy is left above the pavement? Have all dams at rigid pavement joints been removed from the kerfs before pouring the pavement joint sealer?
- _____ 7. Is the level of epoxy and joint sealer around the lights and in the saw kerfs in accordance with plans and specifications? [Epoxy should not be allowed to contact and bond to edge of fixture.]
- _____ 8. Are the bases dry? Water in bases may be unavoidable due to high ground water or other conditions, and design may include drainage provisions. If so, are drainage provisions in place and functional?
- _____ 9. Are all the lights operating?

Table 14.3. Checklist for Medium/Low Intensity Runway and Taxiway Lighting (Elevated, Base Mounted).

Bases

- ___ 1. Are transformer housings of the correct type, size and material?
- ___ 2. Are transformer bases installed level, to proper grade, and with proper bolt pattern orientation?
[Tops of transformer housings should be slightly above surrounding grade in non-paved areas, or flush with grade in paved areas (to keep water away from covers). There should be smooth transition between concrete envelope and surrounding grade. Allowances must be made for spacer rings or pavement rings where used.]
- ___ 3. Are transformer base cover gaskets properly installed, with all bolts properly torqued? [Use only stainless steel bolts; do not reuse shipping bolts unless so intended by the manufacturer.]

Lights

- ___ 4. Are all equipment and materials new, and as specified? Are lamps and isolation transformers of proper wattage? [Items covered by the FAA L-800 series should be listed in the FAA AC 150/5345-53.]
- ___ 5. Are all light locations in accordance with the plans?
- ___ 6. Are the correct filters installed for runway and taxiway edge lights, and light lenses properly oriented for threshold/end? If taxiway lights use masked lamps, are masked lamps properly oriented?
- ___ 7. Are the light fixtures the proper distance from the pavement or defined edge, in a straight line and within tolerance?
- ___ 8. Is the height of light fixtures in accordance with the plans, and frangible couplings properly installed?
- ___ 9. Are all light fixtures plumb and level, with hardware tightened?

Cables

- ___ 10. Are L-823 connectors of proper size for the cable, and are field attached connectors applied properly per details including using terminal crimping tool, cable stripping tool, and heatshrink?
- ___ 11. Are all L-823 Type II two-conductor secondary connectors Class A (factory molded)?
- ___ 12. Is light base properly grounded? Are ground rods installed to minimum depth below grade and within maximum spacing?
- ___ 13. Is counterpoise properly separated from light bases and base grounding provisions?
[The counterpoise/grounding policy may not be the same at each air base. Ensure compliance with plans.]

System

- ___ 14. Are lights labeled in accordance with approved numbering scheme, with proper tag and size of numerals? Are edge light numbering tags facing the pavements?
- ___ 15. Are all new lights operational? Is there any visual evidence of dimming?

Table 14.4. Checklist for Lighted Guidance Signs.

Materials

- ___ 1. Is all equipment and material new? [Items covered by the FAA L-800 series should be listed in the FAA AC 150/5345-53]
- ___ 2. Are L-823 connectors of proper size and do they properly fit the cable? Are they Type II two-conductor secondary connectors Class A (factory molded)?
- ___ 3. Are transformer housings of the correct type, size and material?

Installation

- ___ 4. Are all sign locations in accordance with the plans? [Proper distance from pavement or intersections and collocation with marking]
- ___ 5. Is the correct sign at the proper location? [Correct message face(s), proper orientation with respect to traffic surfaces]
- ___ 6. Is the numbering of signs (sign ID), size of numerals, and method of numbering in accordance with the plans and specifications?
- ___ 7. Are the sign foundations according to plans and specifications? Are tethers installed?
- ___ 8. Has taping/heat shrink for field attached connectors been applied properly, per details?
- ___ 9. Are tops of signs horizontal and are the sign mounts tight?
- ___ 10. Does the height of breakable couplings not exceed the allowable maximum?
- ___ 11. Are the signs connected to the proper circuit as shown on plans?
- ___ 12. Is the plug disconnect for the sign properly installed?
- ___ 13. Are sign and transformer base properly grounding in accordance with the plans, with correct size ground rods installed to a least minimum depth below grade?
- ___ 14. Is counterpoise properly separated from sign and sign transformer base grounding provisions?
- ___ 15. Are transformer base cover gaskets properly installed, with all bolts properly torqued?
[Use only stainless steel bolts; do not reuse shipping bolts unless so intended by the manufacturer.]
- ___ 16. Are all new signs operational?
- ___ 17. Has contractor supplied all necessary maintenance and repair manuals, operating instruction books, and spare parts list? [If spares required, check for correct quantity and type.]

Table 14.5. Checklist for REIL.

- ____ 1. Is all equipment and material new? [Items covered by the FAA L-800 series should be listed in the FAA AC 150/5345-53]
- ____ 2. Are the isolation/interface transformers, if required, of the proper type and capacity as required by the specifications, or as recommended by the REIL manufacturer?
- ____ 3. Are the location of the light units according to plans?
- ____ 4. Is the elevation of the flashheads and associated equipment in accordance with the plans?
- ____ 5. Are the foundations and equipment mountings according to plans, and do breakable couplings not exceed allowable height?
- ____ 6. Is the horizontal and vertical aiming correct?
- ____ 7. Where transformer bases are used to house isolation/interface transformers, are tops of these slightly above surrounding grade to keep water away from the covers? Is there a smooth transition between concrete envelopes of these bases and the surrounding grade?
- ____ 8. Are all L-823 Type II two-conductor secondary connectors Class A (factory molded)?
- ____ 9. Are the base cover gaskets properly installed and the cover properly bolted with stainless steel bolts?
- ____ 10. If connection into series circuit is specified, are the L-823 connectors of proper size and do they properly fit the cable?
- ____ 11. Has taping/heat shrink for field attached connectors been applied properly, per details?
- ____ 12. Has grounding of REIL units, and transformer base if used, been provided in accordance with the plans? With ground rods installed to a least minimum depth below grade?
- ____ 13. Is counterpoise properly separated from REIL units and transformer base grounding provisions?
- ____ 14. Are equipment enclosures weathertight?
- ____ 15. Are all conductor (power and control) connections tight?
- ____ 16. Are the voltages (power and control) within manufacturer specified limits? In case of regulator feed to REIL, are these voltages within limits at those brightness steps at which the REIL operate?
- ____ 17. Is the operation of the REIL in accordance with the plan of operation and specifications?
[Control, rate of flashing, synchronization of slave and master units]
- ____ 18. Has contractor supplied all necessary maintenance and repair manuals, operating instruction books, and spare parts list? If required, have spare parts such as lamps been provided?

Table 14.6. Checklist for PAPI.

- ___ 1. Is all equipment and material new? [Items covered by the FAA L-800 series should be listed in the FAA AC 150/5345-53]
- ___ 2. Is the location of PAPI light boxes according to plans?
[Distance from threshold, distance from runway edge, distance between light boxes.]
- ___ 3. Are the foundations and equipment mountings according to plans, and do breakable couplings not exceed allowable height?
- ___ 4. Is the positioning and aiming of the light units in a bar in accordance with requirements?
 - ___ a. LONGITUDINALLY: In line perpendicular to the runway centerline within ± 6 inches.
 - ___ b. ELEVATION: In a horizontal plane within a tolerance of ± 1 inch, and the centers of the optical aperture of the light units within ± 1 foot of the runway crown.
 - ___ c. AZIMUTH: Parallel to the runway centerline within a tolerance of $\pm \frac{1}{2}$ degree.
 - ___ d. VERTICAL AIMING: Within ± 2 minutes of the specified angle for each light unit.
[Aiming angles should be stencilled on each light box.]
- ___ 5. Is the aiming device and the optical bench properly calibrated and operational? Are the optical systems, if required, properly focused?
- ___ 6. PHOTOCCELL: Is the photocell properly aligned? Does it change the brightness of the lamps? Is the time-delay (45-75 seconds) in the photocell operational?
- ___ 7. Does the tilt switch in each light unit operate when the unit is tilted down between $\frac{1}{4}$ - $\frac{1}{2}$ degree, and also when tilted upward between $\frac{1}{2}$ - 1 degree?
- ___ 8. Does the lamp bypass, if included, operate with each bulb when the bulb is disconnected?
- ___ 9. Is the current in the lamps within the limit for the high and low brightnesses?
- ___ 10. Are the lamps of proper wattage? Is the selected low brightness correct for local conditions?
- ___ 11. Is the voltage at the adapter unit with the facility at full brightness within the specified voltage limits?
- ___ 12. Does the megger test indicate satisfactory cable insulation resistance?
- ___ 13. Has a carrying case for the aiming device been provided?
- ___ 14. In case of adapter-fed PAPI, are the connectors at the breakable couplings of the correct type?
- ___ 15. When regulator feed PAPI system is installed, are isolation transformer connections to the lamp housings made by using cable harness assemblies meeting specification FAA-1041, Figure 5b and 5d?

Table 14.6. Checklist for PAPI (Cont.).

- ____ 16. Are the isolation transformers, if required, of the proper type and capacity as required by specification, or as recommended by the PAPI manufacturer?
- ____ 17. Are the transformer housings/handholes, if required, of the correct type, size, and materials?
- ____ 18. Where transformer bases are used to house the power adapter, are tops of these slightly above surrounding grade to keep water away from the covers? Is there a smooth transition between concrete envelopes of these bases and the surrounding grade?
- ____ 19. If connection into series circuit is specified, are the L-823 connectors of proper size and do they properly fit the cable?
- ____ 20. Has taping/heat shrink for field attached connectors been applied properly, per details?
- ____ 21. Has grounding of PAPI units, and transformer bases if used, been provided in accordance with the plans? With ground rods installed to at least minimum depth below grade?
- ____ 22. Is counterpoise properly separated from PAPI units and transformer base grounding provisions?
- ____ 23. Are equipment enclosures weathertight?
- ____ 24. Are all conductor (power and control) connections tight?
- ____ 25. Has contractor supplied all necessary maintenance and repair manuals, operating instruction books, and spare parts list? If required, have spare parts such as lamps been provided?

Table 14.7. Checklist for Underground Cable and Duct.

Progress Inspection

- ___ 1. Is underground cable the correct type (L-824 Type C for series lighting circuits), and correct size?
[Cable should be marked to show manufacturer or trade mark or catalog number, conductor size, voltage rating, and type.]
- ___ 2. Are conduit and fittings products as required by plans and specifications and applicable standards?
[Size, type, compliance with applicable standards such as UL or Federal Specifications.]
- ___ 3. Are ends of cable taped when cable is on reels, beside the trench or duct bank, in a light base, manhole or handhole, while awaiting connection to an isolation transformer?
- ___ 4. Are the L-823 connectors of proper size and do they properly fit the cable?
- ___ 5. Has taping/heat shrink for field attached connectors been applied properly, per details?
- ___ 6. Is cable installed without kinks or sharp bends, and without splices in the ducts between light bases or manholes/handholes?
- ___ 7. Is trenching done using proper equipment? [Road patrols and graders are not to be used for trenching.]
- ___ 8. Is the counterpoise wire installed as specified and securely attached to ground rods?
[Counterpoise should not be connected to light bases or grounding provisions for manholes and handholes.]
- ___ 9. Do ground rods meet specified requirements and are they installed at required locations?
- ___ 10. Is the depth, elevation, and slope of underground duct in accordance with plans and specifications, and are the size and number of ducts correct?
- ___ 11. Are ducts being cleaned properly?
- ___ 12. Is pull wire being installed in all ducts, with sufficient length in handholes and manholes?
- ___ 13. Are the ends of spare ducts being plugged in manholes, handholes, and boxes at building entrances? Are stubouts being capped?
- ___ 14. Is sufficient cable slack installed at each light and handhole?

Final Inspection

- ___ 1. Does the new underground cable, where connected into the existing lighting circuit, meet the minimum insulation resistance requirements?
- ___ 2. Are high voltage and low voltage cables properly separated in handholes and manholes, and in separate duct, in accordance with the plans and specifications?
- ___ 3. Are the cables identified in all handholes, manholes and wireways?
- ___ 4. Are cables in manholes mounted on non-metallic racks and properly secured? Are cables neatly organized and secured in handholes if racks are not used?

Table 14.7. Checklist for Underground Cable and Duct (Cont.).

- ___ 5. Are cable racks and manhole/handhole frame and covers properly grounded?
- ___ 6. Do ducts terminating in manholes and handholes have end bells, and is duct penetration properly grouted, plugged or sealed?
- ___ 7. Has backfilling and compaction been properly done (no trench settlement), and are disturbed areas properly restored?
- ___ 8. Are cable or duct markers installed at each change of direction, every 200 feet along straight run with no access structure, and at ends of all duct that are not terminated at handholes or manholes?
- ___ 9. Are cable and duct markers correctly and neatly inscribed?
- ___ 10. Is sufficient cable slack provided at each primary connector termination?
- ___ 11. Does the cable insulation meet the minimum resistance requirements?

Table 14.8. Checklist for Vault. (1 of 4)

Equipment

- ___ 1. Is installed equipment and material new? [Items covered by the FAA L-800 series should be listed in the AC 150/5345-53. Furnished equipment and material other than that covered by the FAA L-800 series must be in accordance with the requirements of all applicable contract plans, specifications, standards (such as UL), and approved shop drawings with regard to quality, quantity, capacity, size, and type]
- ___ 2. Have shop drawings for all major equipment items (switches, power panels, cutouts, etc.) been submitted by the contractor and approved by the engineer?
- ___ 3. Are all switches, panels, breakers, contactors, and relays installed in proper enclosures, and are panels and switches pull/junction boxes of the correct type and size and easily accessible?
- ___ 4. Does specially made equipment, such as relay/contactor/interface panels, or terminal block cabinets, meet applicable specifications?
- ___ 5. Is the wall mounted equipment properly and securely mounted, and is the floor mounted equipment sufficiently raised above the floor?
- ___ 6. Are the covers of electrical equipment identified as to function, voltage and phase?
- ___ 7. Is labeling/stenciling of proper color, size and material? Are high voltage warning signs installed where required?
- ___ 8. Have no equipment cabinets been used as pull/junction boxes?
- ___ 9. Have all necessary maintenance and repair manuals, operating instruction books, and spare parts lists been supplied by the contractor?
- ___ 10. Is there sufficient space for operation of high voltage (HV) disconnects, and are all HV disconnects properly protected against accidental contact with the human body?
- ___ 11. Does no switch interrupt neutral?
- ___ 12. Are all breakers of correct size and all switches fused correctly to protect the connected conductors? Are spare fuses furnished (if required)?
- ___ 13. Are the phases sufficiently balanced?
- ___ 14. Are all knife switches placed so that gravity will not tend to close them?
- ___ 15. If oil-type, is the oil level acceptable in L-828/9 regulators and oil-filled transformers?
- ___ 16. Where radio control of field lighting is provided, is the control unit functioning properly and in accordance with the plan of operation?
- ___ 17. Is the location, mounting and wiring of the L-854 radio control equipment and it's antenna in accordance with the plans and specifications?
- ___ 18. Are the lightning arresters vertically mounted, of correct rating and properly connected?
- ___ 19. Are framed wiring and schematic diagrams, if required, provided in the vault?

Table 14.8. Checklist for Vault (Cont., 2 of 4).

Duct/Conduit

- ___ 1. Are all conduits of the type specified?
- ___ 2. Are all conduit sizes in accordance with the NEC, and are proper bushings installed at conduit terminations?
- ___ 3. Are all bends made in accordance with the NEC, and is the number of bends in one conduit run within allowable limits?
- ___ 4. Are all steel conduit galvanized?
- ___ 5. Are all conduit entering the vault from outdoor duct sealed?
- ___ 6. Are all exterior conduit made rain-tight?
- ___ 7. Are all conduit cover plates installed and open knock-out holes in boxes/panels covered?
- ___ 8. Are all empty conduits that do not terminate at equipment or junction boxes properly capped?
- ___ 9. Are the square duct of the correct type and size and with covers hinged at the bottom?

Wiring

- ___ 1. Is the power and control wiring in accordance with applicable diagrams?
- ___ 2. Are all circuits continuous and free from shorts and unspecified grounds?
- ___ 3. Are the power and control conductor types and sizes as specified, and are all conductors of proper voltage rating?
- ___ 4. Where wire sizes are not specified, are they of sufficient ampacity to carry the presently connected and future loads?
- ___ 5. Are the power and control wiring connections to terminals tight, and are the terminal lugs of proper size for conductors and connected?
- ___ 6. Are the wires laced together and does the finished work present a neat and professional appearance?
- ___ 7. Do all wire terminations have enough slack to permit natural movement due to temperature changes and magnetic forces?
- ___ 8. Are all conductors properly identified?
- ___ 9. Are the branch circuits color coded in accordance with applicable specifications?
- ___ 10. Is the number of wires in conduit and junction boxes within the allowable limits of the NEC?
- ___ 11. Are HV and LV cables properly separated in accordance with the NEC?

Table 14.8. Checklist for Vault (Cont., 3 of 4).

Grounding

- ___ 1. Are the tops of ground rods at the required depth below grade?
- ___ 2. Are all the ground rods serving the vault tied together by the use of bare copper wire?
- ___ 3. Is the grounding wire size in accordance with the plans and/or the NEC?
- ___ 4. Is the grounding wire protected in accordance with plans and/or the NEC?
- ___ 5. Are all metallic pull boxes, raceways, cabinets, cable armor, transformer enclosures, and cages properly grounded, and are the grounding wires connected to the metal surfaces with proper lugs and connectors? [Metal surface must be cleaned of paint and grease where the ground connections are made.]
- ___ 6. Is the power neutral grounded only at the power service entrance?
- ___ 7. Are the neutrals of the secondary distribution systems properly grounded?

Tests

- ___ 1. Does the cable of each series and parallel lighting circuit meet the minimum insulation resistance requirements?
- ___ 2. Is the supply voltage to regulators within acceptable limits?
- ___ 3. Are the output current values of each regulator at each intensity step within allowable limits?
- ___ 4. Is the open circuit protective device of each regulator functioning properly?
- ___ 5. Has each control been operated the required number of times and are they functioning properly, at each control location?
- ___ 6. Has each lighting circuit been operated at each brightness step for the required number of hours and are they functioning properly?
- ___ 7. Is the ground resistance equal or less than the specified value? [Measure with vault neutral disconnected from power company's neutral.]
- ___ 8. Is photocell, if required, operating properly?
- ___ 9. Is the entire lighting system functioning in accordance with the approved plan of operation?

At Final Inspection

- ___ 1. Does new underground cable meet the minimum insulation resistance requirements?
- ___ 2. Are high voltage and low voltage cables properly separated in handholes and manholes, and in separate duct, in accordance with the plans and specifications?

Table 14.8. Checklist for Vault (Cont., 4 of 4).

- | |
|--|
| _____ 3. Are the cables identified in all handholes, manholes and wireways? |
| _____ 4. Are cables in manholes mounted on non-metallic racks and properly secured? Are cables neatly organized and secured in hanholes if racks are not used? |
| _____ 5. Are cable racks and manhole/handhole frame and covers properly grounded? |
| _____ 6. Do ducts terminating in manholes and handholes have end bells, and is duct penetration properly grouted, plugged or sealed? |
| _____ 7. Has backfilling and compaction been properly done (no trench settlement), and are disturbed areas properly restored? |
| _____ 8. Is sufficient cable slack provided at each primary connector termination? |
| _____ 9. Does the cable insulation meet the minimum resistance requirements? |

14.4. Cable, Connector, and Isolation Transformer Inspection. The primary and secondary cable leads of the transformers are supplied with factory-installed molded connectors. Visual inspection of these items during installation is very important. Minor cuts, bruises, or mishandling may result in a progressive deterioration which will eventually cause complete failure, but not until some time after acceptance tests. During installation, the following items must be inspected (see also checklist table 14.7):

14.4.1. Connectors. The mating surfaces of molded connectors are to be clean and dry when plugged together. If clean and dry inside, these high voltage connectors, with taping, form a connection equal or superior to a conventional high voltage splice. Conversely, if they are wet or dirty inside, taping will not produce a satisfactory connection. Two or three turns of tape, or heat shrink tubing, should be used to hold the connector together and keep the parting line clean. Cleanliness of mating surfaces can be ensured by keeping the factory-installed caps in place until the final connection is made. The mating surfaces of uncapped connectors should not be laid down, touched, or breathed upon. If a connection must be broken the connectors should be immediately capped.

14.4.1.1. The connectors are to be completely plugged together. After initial plugging, trapped air pressure may partially separate the plug and receptacle. If this happens, wait a few seconds and push them together again. Two or three turns of tape should be used to hold them in place.

14.4.2. Cables:

14.4.2.1. The cables are not to be cut by shovels, nicked, crushed by vehicle wheels, bruised by rocks, or damaged in any way during handling and installation.

14.4.2.2. The cables are to be buried to the specified depth below finished grade, and all other detailed requirements of the installation specification must be met.

14.4.2.3. The cables should not directly cross each other and must be separated by the specified distance.

14.4.2.4. Screened material should be placed under and over the cables, and rocks or pebbles should not contact the cables.

14.4.2.5. The cables are not to be bent sharply where they enter (or leave) a conduit, and should be supported properly by tamped ground so future settling will not cause sharp bends.

14.5. Cable Electrical Tests. Test cables directly buried in earth (that is, not in duct or conduit) before and after the trench is back-filled. Test each underground circuit as follows:

14.5.1. Continuity ohmmeter or equivalent continuity test on each series circuit. The circuit should then be checked with a megger test set, to make sure it is free of grounds. Any faults indicated by these tests should be located and repaired before proceeding with high voltage tests.

14.5.2. High voltage insulation resistance test on each series and multiple underground circuit to determine complete freedom from grounds. Whenever possible, these tests must be performed when the ground is thoroughly wet because circuit wiring that passes insulation resistance tests during dry weather may fail after a heavy rain.

14.5.2.1. The test procedure follows for each circuit:

14.5.2.1.1. Disconnect both leads from the regulator output terminals. Support both leads so there are air gaps of several inches between bare conductors and ground. Make sure the cable sheath is clean and dry for a distance of at least 300 millimeters (1 foot) from the end of the cable. Also make sure exposed insulation at the end of the cable is clean and dry.

14.5.2.1.2. Test each circuit immediately after installation according to “First Test on New Circuit.” Test any circuit installed for 60 days or more, even if it has not been operated, according to “Succeeding Old Circuit.” (See table 14.9.)

14.5.2.1.3. The maximum acceptable leakage current, in microamperes, should not exceed the values in paragraph 14.5.2.4.

14.5.2.1.4. When additions are made to old circuits, test only the new sections according to “First Test on New Circuits.” Test the complete circuit at the reduced voltages to ensure reliable operation. See table 14.9.

14.5.2.1.5. Connect both conductors, and apply the test voltage shown for 10 minutes between conductors and ground.

Table 14.9. Cable/Circuit Test Procedures.

	First Test on New Circuit	Succeeding Old Circuit
Complete Approach System (5,000V leads, 500 and 300W transformers)	1.5 x max. working V	1,000V
Touchdown Zone and Center-line Light Circuits (5,000V leads, 200W transformers)	1.5 x max. working V	1,000V
High Intensity Runway Edge Light Circuits, (5,000V leads, 500 and 200W transformers)	1.5 x max. working V	1,000V
Medium Intensity Runway and Taxiway Circuits (5,000V leads and 30/45W transformers)	1.5 x max. working V	1,000V
600 Volt Circuits	1.5 x max. working V	600V

14.5.2.2. The above tests must be performed with a suitable high voltage DC tester that has a steady, filtered output voltage. The high voltage tester must have an accurate voltmeter and microammeter for reading the voltage applied to the circuit and the insulation leakage current.

14.5.2.3. All high voltage tests on airfield lighting circuits must be carefully supervised by qualified government personnel to ensure that excessive voltages are not applied to circuits.

14.5.2.4. During the last minute of the above tests, the insulation leakage current in microamperes for each complete circuit must not exceed the following value calculated for each circuit:

14.5.2.4.1. Allow 2 microamperes for each 30/45, 100, 200, 300 and 500W series transformer tested at voltage shown in table 14.9.

14.5.2.4.2. Allow one microamperes for each 300 feet of cable tested at voltage shown in table 14.9. This value includes allowances for the normal number of connectors and splices.

14.5.2.4.3. Using a 1000 volt DC crank-type megger, each circuit must measure above 30 megohms to be satisfactory.

14.5.2.5. If the leakage current exceeds the value calculated as outlined above, the circuit must be sectionalized and the above test repeated for each section. Defective components must be located and repaired or replaced until the entire circuit passes the test.

14.5.2.6. Make sure the test voltage specified in paragraph 14.5.2.1 is applied to a circuit in the final acceptance test. The voltage should be adjusted so the voltmeter reads the desired value before the leakage current is read. If there is a difficulty in obtaining the desired voltage, either the circuit being tested or the test set is defective and should be corrected before the test is continued. Maintain a log book of the circuit readings and pass this on to the maintenance section for airfield lighting.

14.5.2.7. On new circuits, a megger test check should be made immediately after the circuit has passed the high voltage tests. This megger reading then can be used by maintenance personnel for a comparison with further readings to determine the circuit conditions. Ambient temperature and weather conditions should be recorded at the time of test.

14.6. Constant Current Regulator Inspection. Each constant current regulator must be inspected to ensure that porcelain bushings are not cracked, no shipping damage has occurred, connections are correct, switches and relays operate freely and are not tied or blocked, fuses (if required) are correct, and the oil level of oil-filled regulators is correct. Only relay panel covers must be removed for this inspection; the main tank of oil-filled regulators need not be opened. Information on the regulator instruction plate must be followed. All covers must be cleaned and tightly replaced after inspection and tests are completed. (See also checklist for vault table 14.8.)

14.7. Regulator Electrical Tests. The supply voltage and input tap must be checked to see that they correspond:

14.7.1. With the load disconnected, energize the regulator once and see if the open-circuit protector de-energizes the regulator within 3 seconds.

14.7.1.1. Connect the load circuit (after it has been tested for opens and grounds as specified in paragraph 14.5 and inspected to ensure all fixtures are properly lamped).

14.7.1.2. Using only an ammeter, calibrated with an accuracy of $\pm 3\%$, measure input voltage and output current simultaneously at the highest brightness step. Note that when measuring output voltage, the accuracy can be less since the potential transformer to be used will have some built-in tolerance. Following are suggestions to ensure successful measurements:

14.7.1.2.1. Use proper equipment. Laboratory quality instrumentation generally give readings within $\pm 1\%$ accuracy, while standard grade multimeters, potential transformers, and current transformers may have more than 5% error.

14.7.1.2.2. Suggest using power analyzers with a scaling feature allowing for internal conversion of current transformer and power transformer ratios, eliminating need to multiply in power transformer and current transformer ratios. The phase relationship between the power transformer and current transformer secondaries will affect the reading if not connected properly (in phase) to the power analyzer, and watts and volt-amperes (VA) will fluctuate or indicate low. If this occurs, simply swap polarity on either power transformer or current transformer secondary at the connection to the power analyzer.

14.7.1.2.3. The load should warm up at least 5 minutes before taking readings.

14.7.1.2.4. Use the lowest ratio possible on the current transformer without over-ranging the current input on the power analyzer. Never connect the airfield load directly to the power analyzer; output voltages on constant current regulators (CCRs) can exceed 4,500V.

14.7.1.2.5. If REIL lights are connected to the series lighting circuit, this will cause fluctuation in the VA and watt readings. Manually shut off the REIL lights before taking readings, then add REIL load. Note that REIL systems require spare capacity in the CCR to operate properly. Consult the REIL manual for power requirements.

14.7.1.2.6. Measurements will vary with soil and weather conditions. The best days for taking readings are when the ground is wet.

14.7.1.3. Use a recording voltmeter or take readings during both day and night at intervals of one hour to obtain an average supply voltage.

14.7.1.4. If the regulator has input voltage taps, select the tap which most nearly corresponds to the average supply voltage. The output current on each brightness tap should be within the current limits of FAA AC 150/5345-10 after any necessary supply voltage correction is made.

14.7.2. In some current regulators with input voltage taps, the output current will vary in proportion to input voltage changes. In all cases the output current values must be within the current limits of FAA AC 150/5345-10.

14.7.3. For regulators which have automatic supply voltage correction instead of input taps, the output current must be within the current limits of FAA AC 150/5345-10.

14.7.4. The following tests are not mandatory, but will help locate the trouble if the above test indicates improper operation:

14.7.4.1. De-energize and lock out regulator, disconnect the load, short-circuit the output terminals with jumper, re-energize regulator observing all safety precautions, and measure the output current with clamp-on ammeter. If measured values are equal to nameplate values and within the current limits of FAA AC 150/5345-10, the regulator is operating satisfactorily. Check the load circuit for faults.

14.7.4.2. Connect load cables (after the circuit has been tested for opens and grounds, as specified in paragraph 14.5, and inspected to ensure all fixtures are properly lamped) and measure output current and output voltage simultaneously with the regulator operating on the highest brightness tap. The significance of the readings is as follows:

14.7.4.2.1. Satisfactory operation is indicated by correct output current and an output voltage which is slightly higher than the estimated load voltage and does not exceed the rated output voltage. The measurement of the load voltage must be compared with the design load voltage calculated by the design engineer. An example of this calculation is shown in figure 15.4.

14.7.4.2.2. A correct output current, with an output voltage appreciably less than the estimated load voltage, indicates complete or partial shorting of the load.

14.7.4.2.3. A correct output current, with an output voltage exceeding the rated load output voltage, indicates an overload.

14.7.4.2.4. A reduced output current, with an output voltage exceeding the rated load output voltage, indicates an overload, possibly caused by a poor connection in the load circuit. The regulator should be de-energized immediately to prevent damage.

14.7.4.2.5. A reduced output current, with an output voltage not exceeding the rated output voltage, indicates a faulty regulator or reduced supply voltage.

14.7.4.2.6. A zero output current, with excessive output voltage, indicates an open in the load circuit and failure of the open-circuit protector in the regulator. The regulator should be de-energized immediately to prevent serious damage.

14.8. Lighting Fixture Inspection. An inspection must be made to determine that the color, quantity, and locations of lights meets the installation drawings. Each light must be inspected to determine that it operates, is properly leveled and aimed, glass is not broken or cracked, and correct lamps are installed, all according to the technical orders and manufacturer's instructions. (See also checklists for lights, signs, and other visual aids, tables 14.1 through 14.6.)

14.9. System Miscellaneous Components Inspection. Components such as control panels, relay cabinets, or panelboards, must be visually inspected for damage, correct connections, proper fuse and circuit breaker ratings, and compliance with the installation drawings. (See also checklist for vault, table 14.8.)

14.10. System Operation. After components and circuits have been inspected and tested, as specified in the preceding paragraphs, the entire system must be tested as follows:

14.10.1. Procedures:

14.10.1.1. Operate each switch of the airport lighting and taxiway panel in the control tower so each switch position is reached at least twice. During this process, observe all lights and vault equipment to determine that each switch properly controls the corresponding circuit.

14.10.1.2. Repeat the above test for the panel in the alternate control station (vault) and then repeat it again, using the local control switches on the regulators.

14.10.1.3. Operate each lighting circuit continuously at highest brightness step for 15 minutes maximum, and continuously at least 3 hours at middle intensity. Make a visual inspection at the beginning and end of this test to determine that the correct number of lights are operating at full brightness. Dimming of some or all of the lights in a circuit is an indication of grounded cables. In addition, measure the lamp terminal voltage on at least one light in each multiple circuit to determine that it is within ± 1 percent of the rated lamp voltage marked on each lamp.

14.11. Additional Guidance. Additional guidance on acceptance testing is in the FAA Advisory Circulars listed in Chapters 12 and 13.

Chapter 15

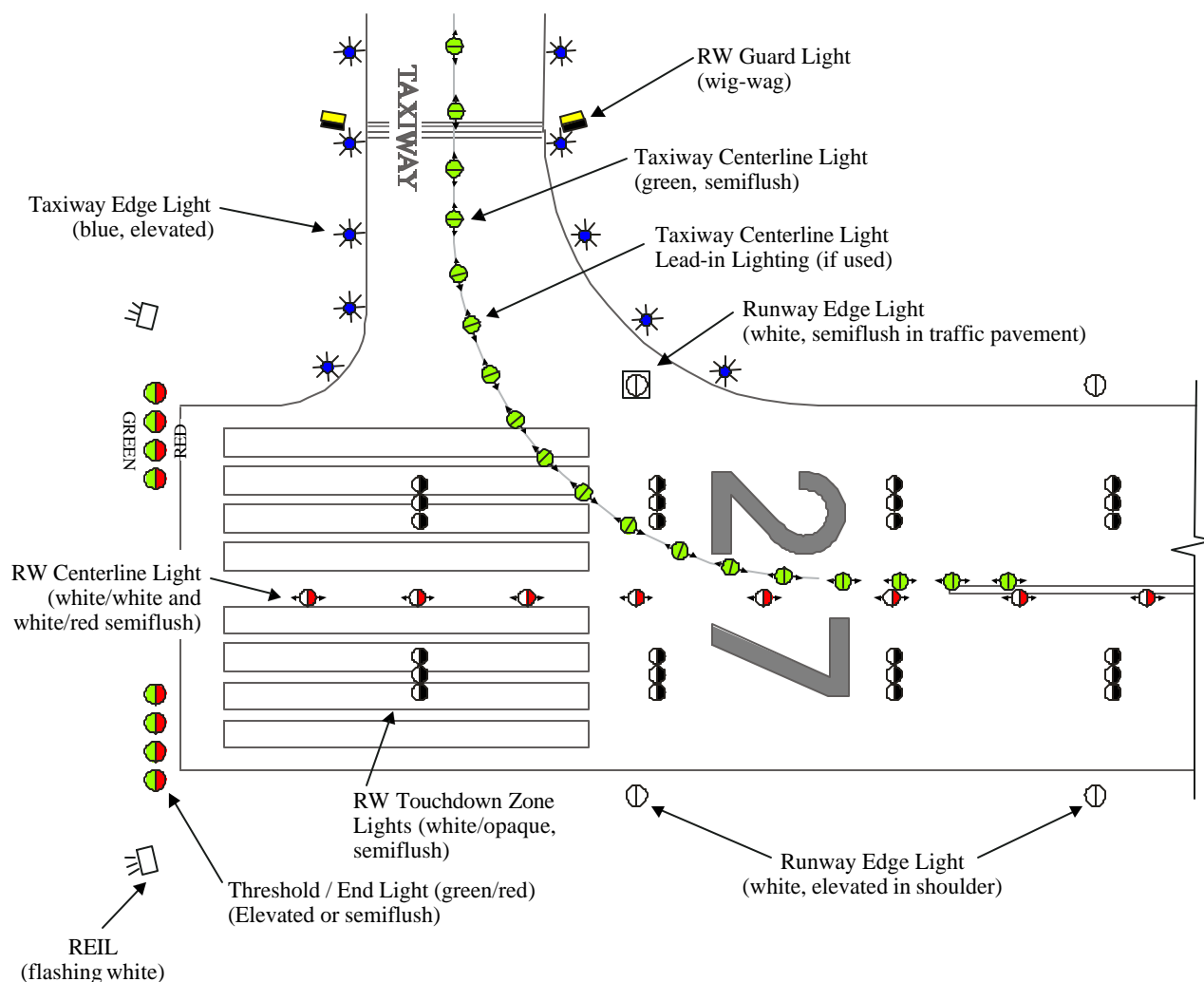
CHARACTERISTICS OF AIRFIELD GROUND LIGHTING

15.1. General. Airfield ground lighting (AGL) typically includes separate series-circuited lighting systems that provide visual guidance to the pilot for aircraft operations. The systems usually have brightness control for

adapting to various visibility conditions. The types of lighting systems installed for a particular runway are an important part in determining the conditions under which aircraft operations are allowed (i.e., VFR, Category I or Category II). The various lighting systems that may be installed for a runway are shown in figure 15.1. Not included in this figure are the several approach lighting systems (ALS) which may also be installed. Details for lighted approach aids, runway lighting systems, and taxiway lighting are provided in Chapters 3, 4 and 5, respectively.

15.1.1. Airfield ground lighting is characterized by constant current series electrical circuits, which provide constant current for intensity control of lighting components. This system allows for selectively changing the brightness of the lighting components by increasing or decreasing the level of the constant current in the series loop. While some older systems use constant voltage for shorter length series circuits, most systems today are constant current type. The series circuit provides energy at constant current to each device (such as a light or sign) on the circuit, supplied from a CCR.

Figure 15.1. Typical AGL Layout.



NOTES:

1. **RW EDGE LIGHTING:** For high intensity system (HIRL) bidirectional, white/white, with yellow on rollout for last 610M (2,000') (L-862 elevated, with L-850C for semiflush). Runway edge lights are spaced about 61M (200') apart.
2. **THRESHOLD/END (T/E) LIGHTS:** Group of 4 or 5, spaced 3M (10') apart symmetrical about centerline. Outer light in each group lines up with RW edge lights. Groups may be wing-out bars, where inner light in each group lines up with RW edge lights.

T/E lights show green to aircraft approaching for landing, and red to landing aircraft coming to end of the RW.
3. **RW CENTERLINE LIGHTS:** Bi-directional white/white, with alternating red/white and white/white from 915M to 610M (3,000' to 2,000') from end of RW, and red/white for last 610M (2,000') of RW.
4. **RW TOUCHDOWN ZONE LIGHTS:** Uni-directional, with white towards approaching aircraft.
5. **TW EDGE LIGHTS:** Omni-directional blue (L-861T).
6. **TW CENTERLINE LIGHTING:** Bi-directional green/green, but may be green/yellow or yellow/yellow for some conditions.
7. **REIL:** Runway End Identifier Lights, discharge type flashing white lights (about 90 times/min.), Aimed 15 deg outward and 10 deg above horizontal.
8. **RW GUARD LIGHT:** Uni-directional, flashing yellow. Elevated outside TW, or may be bar of semiflush across pavement (L-804).

15.1.2. The major parts of a series circuit are: the CCR (power source), the primary circuit cable, isolation transformers, and lighting components (such as lights and signs). The isolation transformers are connected in series on the primary side, with connected loads on the secondary side of each isolation transformer (figure 15.2). The system is characterized as follows:

15.1.2.1. A constant current is delivered along the entire loop on the primary side of the isolation transformers, independent of the number of lighting loads. Power is provided by the CCR.

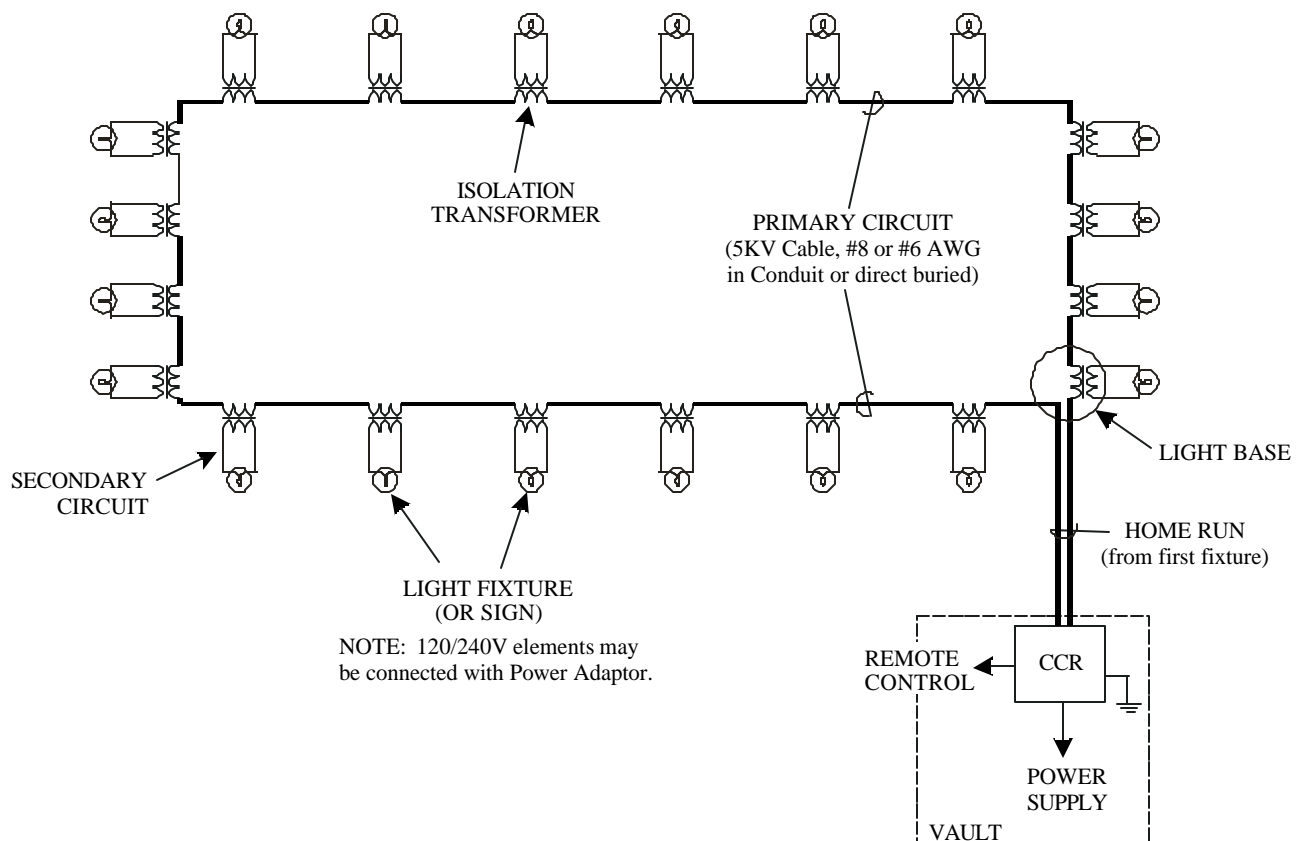
15.1.2.2. The magnitude of the voltage along the series circuit primary depends on the number and size of connected lighting loads. The voltage along the primary cable will measure different at each point. (Calculating voltages for the constant current series circuit is illustrated later in this chapter.)

15.1.2.3. The circuit is considered high voltage on the primary side, which typically may be several thousand volts (5kV cable is used), and low voltage on the secondary side or load side of the isolating transformers, which typically is less than 30V.

15.1.2.4. The isolation transformer provides an effective short for the primary circuit in the event of a lamp filament failure, which opens the secondary circuit. This prevents failure of a connected light from causing an open condition on the series primary circuit.

15.1.2.5. A constant current series circuit can also be used to power equipment with specific voltage requirements. In this case a power adapter is used. The power adapter also serves to isolate the device from the primary side similar to an isolation transformer. Examples of equipment which may be connected to series lighting circuits include: windcones, PAPI, REIL, and others which typically may require 120/240V power. The lighting circuit must be ON for the equipment to receive power with this type of arrangement.

Figure 15.2. Typical AGL Series Lighting Circuit.



15.1.3. Parallel circuits are briefly discussed as these may be used to serve facilities such as wind cones, PAPI, REIL, and others. This may be directly from a power source, or via power adapter from a series lighting circuit.

15.2. Power. Upstream power for the CCR feeding the AGL may be from a variety of sources. Equipment vaults for AGL may be fed from a variety of sources, and in many cases have emergency standby generator power with automatic transfer in case of outages. Older systems typically feed the CCR at 2400V, while newer installations feed vault CCRs at 480V or 240V (used for some smaller installations). The upstream power distribution feeding the CCR is not covered in this section.

15.3. Control and Monitoring Systems. Traditional control/monitoring systems, both military and commercial, are relay systems. L-821 relay panels are very reliable and are suitable for nearly all military airfields. Typically, cables required for these types of systems are multi-pair (50 or more pairs) cables to connect the airfield lighting vault on the airfield with the air traffic control tower. On many air bases, the distance between the two facilities is great, resulting in a costly cable installation with the cable vulnerable to possible damage or failure of one or more pairs in the cable. In addition, these communications cables require separate duct systems to eliminate interference from the power cables. The traditional relay panel and multi-conductor control cable can also be simplified by using a multiplexer, which requires only one pair cable to communicate between the vault and tower (or other station). A multiplexer can also be built into a PLC system.

15.3.1. Some airfield control/monitoring systems have been installed using Programming Logic Controllers (PLCs), which have good industrial standards and proven reliability. The PLC industrial systems use high I/O modules that reduce the need for multipair cable installation. Cables with 2 to 6 pairs are typically needed, although fiber optic cable can also be used.

15.3.2. PC-based systems have come into use, with computers located in the tower, the vault, and/or other work stations. Reliable standards for PC equipment do not exist at this time. These systems have the capability of displaying the necessary information on a monitor. This is the most flexible system in use today, with off-the-shelf units readily available. Typically, standard operating software is used, and off-the-shelf graphics software is tailored for a specific site. The communications cable requirements are 2 to 6 pairs of cable or fiber optics. Fiber optic cable eliminates the need for separate ducts since there will be no interference between power cable and fiber optic cable.

15.3.3. Compared to the traditional FAA Type L-821 control/monitoring systems, the PLC or PC based systems are easily expanded and provide data for the controller and maintenance personnel. At this time, the FAA has not issued design standards for PC or PLC based systems, but commercial standards are available for the components of such systems. Some industrial standards the PLCs meet are NEMA ICS1, *Industrial Control and Systems General Requirements*, NEMA ICS2, *Industrial Control and Systems Controllers, Contractors, and Overload Relays Rated Not More than 2000 Volts AC or 750 Volts DC*, NEMA ICS 3, *Industrial Control and Systems Factory Built Assemblies*, UL 508, *UL Standard for Safety Industrial Control Equipment Seventeenth Edition; Reprint with Revisions through and including 7/16/99*, ANSI/IEEE C 37.90.1-1989, *Standard Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems*, CAN/CSA C22.2 No. 142, *Process Control Equipment*, MIL-STD-461B, MIL-STD-810, *Department of Defense Test Method for Environmental Engineering Consideration and Laboratory Tests*, and ISO 9000, *Quality Management and Quality Assurance Standards*.

15.3.4. Often, the computerized system is based on one specific manufacturer's equipment, locking the facility to one manufacturer for servicing and parts. A good system design will avoid this trap by establishing

competitive parameters in the procurement document. It should be pointed out that the newer systems may have a slight delay between the control action by the tower and the response from the field, compared to the instant response of the relay systems. This may result in a short moment of possible uncertainty as to whether the action requested has been accomplished. Maximum delay should not exceed 2.0 seconds.

15.3.5. Considerations for the design of a computerized control/monitoring system are in paragraph 13.16.

15.3.6. Several factors should be considered in deciding between a PLC or a PC based system. Some considerations are:

15.3.6.1. Monitoring AGL equipment the PLC system must be customized for each type of CCR, since to date there is no PLC software combination that is available or easily configured for this task.

15.3.6.2. For PC based systems, software has been developed and tested, and is easily configured to monitor AGL equipment. Software developed for PC systems is specific for the task and works with all types of CCRs and other related AGL equipment.

15.3.6.3. With PLC systems there are established industrial standards and criteria for mean-time-between-failure (MTBF).

15.4. Constant Current Series Circuits. A constant current series circuit is an ungrounded system, where circuit elements are connected in a string with the same current flowing to each element. The circuit is one continuous loop starting and ending at the power source (the constant current regulator for the AGL circuit). The CCR maintains a constant current independent of the load on the circuit.

15.4.1. With constant current, a short-circuit across the output of the CCR is a no-load condition, and an open-circuit is an overload. In a simple series circuit, a lamp failure would cause an open-circuit. For this reason a bypass device such as an isolating transformer is installed between the primary side and secondary side as part of each light fixture connection, or for connecting other loads such as guidance signs. In certain cases, such as for approach lights where 5 steady-burning lights are on a single secondary circuit isolated from the primary series circuit by one or more isolation transformers, a film disc cutout may be used. Film disc cutouts operate in such a way that when a lamp burns out, the film-disc cutout shorts the failed lamp, thereby allowing current to flow to the remaining connected fixtures.

15.4.2. Advantages of series lighting circuits are:

15.4.2.1. All lamps operate at the same current, hence same intensity.

15.4.2.2. Single-conductor cable of one size and insulation voltage rating can be used throughout the circuit.

15.4.2.3. Intensity control of lights can be obtained over a wide range.

15.4.2.4. A single ground fault along the circuit will not affect light operation.

15.4.2.5. Ground faults are easily located.

15.4.3. Major disadvantages of series lighting circuits are:

15.4.3.1. Installation costs are high when considering the CCR and isolating transformers.

15.4.3.2. Poor efficiency in use of electrical power.

15.4.3.3. All components on the primary side must be insulated for full voltage.

15.4.3.4. An open-circuit anywhere on the primary side makes the entire circuit inoperative and could damage cable insulation or the CCR.

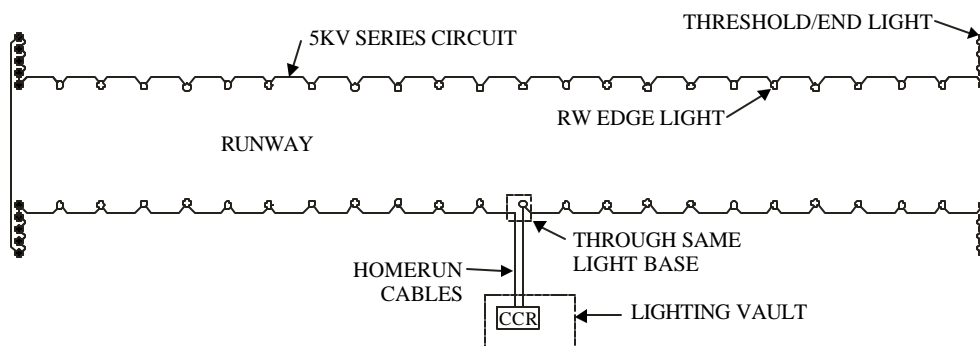
15.4.3.5. Locating faults such as open-circuit conditions can be time-consuming and may be difficult.

15.4.4. Series circuits are usually used for runway and taxiway lighting systems and most steady-burning lights of approach lighting systems because they provide more uniform intensity and better intensity control of the lights.

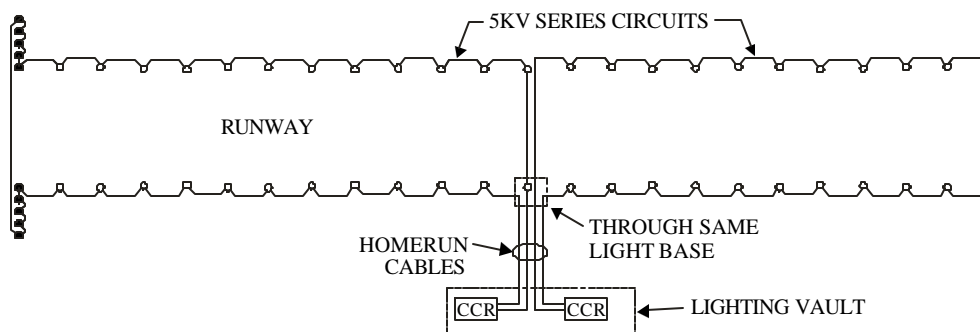
15.4.5. Circuit Configurations. Three methods for configuring runway edge lighting series circuits are shown in figure 15.3.

Figure 15.3. Series Circuits.

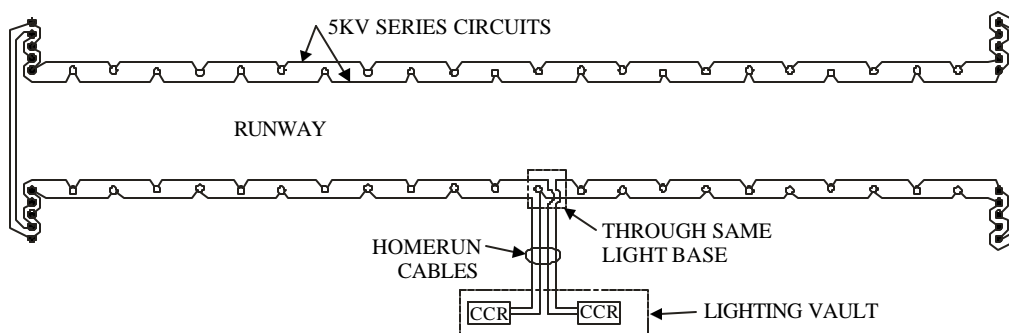
A. SINGLE CIRCUIT.



B. SPLIT CIRCUITS.



C. TWO CIRCUITS INTERLEAVED.



- NOTES: 1. EXAMPLES ABOVE ARE ILLUSTRATIONS OF THREE WAYS TO CIRCUIT RUNWAY EDGE LIGHTING.
2. INBOARD IN-PAVEMENT THRESHOLD LIGHTS SHOULD ALTERNATE BETWEEN APPROACH LIGHT CIRCUIT AND RUNWAY EDGE LIGHT CIRCUIT(S).
3. TYPES OF SIGNS THAT MAY BE CONNECTED TO RUNWAY EDGE LIGHTING: RUNWAY EXIT SIGNS, MANDATORY HOLD SIGNS, MARKERS. OTHER SIGNS SHOULD BE CONNECTED TO TAXIWAY CIRCUITS.
4. DO NOT ALLOW MORE THAN ONE PRIMARY CIRCUIT TO BE INSTALLED IN ANY ONE CAN OR LIGHT BASE. USE CANS TO ISOLATE PRIMARY CIRCUITS.

15.5. Constant Current Regulators. The power input to the AGL circuits is controlled by the CCR to which the circuit is connected. While the CCR produces constant current to the circuits depending on the brightness step setting, the voltage input to the circuit varies with the actual load.

15.5.1. Basically, there are three types of constant current regulators used at airports:

15.5.1.1. Resonant Network Circuit (a dry type using a resonant network control system to produce output current).

15.5.1.2 Saturable Reactor (liquid type, where degree of reactor saturation via closed control loop determines output current).

15.5.1.3. Silicon Controlled Rectifier (SCR) (uses SCR type thyristors to convert constant voltage source to constant current output, with solid state control circuiting).

15.5.2. The first two types have been reliable over the years, but fluctuations in input voltage will cause corresponding changes in the output current. Most CCRs now manufactured are SCR type.

15.5.3. The method of control for SCR regulators is very accurate over a wide range of loads and varying input voltage, although the high precision produces harmonics that can cause overheating and noise in the CCR. The degree to which harmonics can be tolerated depends on the susceptibility of the load or power source to the harmonics. The most susceptible types of equipment are those which require a sinusoidal input.

15.5.4. Tests have shown that, as circuit load increases toward the rated capacity of a CCR, harmonic distortion is reduced and the wave form approaches a sine wave. This suggests that loading closer to rated capacity results in better circuit performance. However, lamp failures and other factors may increase the output voltage, and this needs to be considered when matching circuit load to CCR size.

15.5.5. CCRs have “taps” for adjustment to accommodate loads. Some manufacturers have introduced taps which automatically adjust to the circuit load, while others use manual taps which are typically set when the CCR is installed, but can be changed later to accommodate changes in the load.

15.5.6. The allowable tolerances in CCR output current are shown in tables 15.1, 15.2 and 15.3. The allowable tolerances are small, since small changes result in large changes in light output. For a 6.6 amp circuit, reducing the current by 3% (to 6.4 amps) will reduce the light output over 15%, and reducing the current by 6% (to 6.2 amps) will reduce the light output by over 30%. The impact is the opposite on lamp life, where a current lower than maximum will significantly increase lamp life, and a higher current will reduce lamp life. The percent of full brightness obtained at each of the nominal current levels for 3 and 5 step systems can be found in paragraph 12.1.11.

Table 15.1. 5-Step 20-ampere Circuit (FAA Class 2, Style 2).

Brightness Step	Nominal Current	Allowable Tolerance Current (amperes) (amperes)
5	20.0	19.4 - 20.30
4	15.8	15.33 - 16.27
3	12.4	12.03 - 12.77
2	10.3	9.99 - 10.61
1	8.5	8.24 - 8.76

Table 15.2. 5-Step 6.6-ampere Circuit (FAA Class 1, Style 2)

Brightness Step	Nominal Current	Allowable Tolerance Current (amperes) (amperes)
5	6.6	6.40 - 6.70
4	5.2	5.04 - 5.36
3	4.1	3.98 - 4.22
2	3.4	3.30 - 3.50
1	2.8	2.72 - 2.88

Table 15.3. 3-Step 6.6-ampere Circuit (FAA Class 1, Style 1)

Brightness Step	Nominal Current	Allowable Tolerance Current (amperes) (amperes)
3	6.6	6.40 - 6.70
2	5.5	5.33 - 5.67
1	4.8	4.66 - 4.94

15.5.7. CCRs larger than 30KW are rated at 20 amperes output current, while smaller CCRs are rated at 6.6 amperes output current. 15KW through 30KW CCRs may be selected for either 20 or 6.6 amperes output current. Intensity steps are either 5-step or 3-step.

15.6. Sizing the Regulator When REIL are Connected to the Circuit. In its Advisory Circulars, the FAA does not address the load imposed on the CCRs by the constant current to constant voltage adapters necessary for REIL operation, or the REIL that are connected into series circuits. With the constant flashing of the lights and the resulting discharging of the capacitor, the REIL place a very short, but heavy, pulsing load on the regulator. Occasionally, this type of pulsing load results in pulsation of the illumination of the steady burning lights on the circuit. This “reflective” pulsation depends on the characteristics of the regulator powering the circuit and on the characteristics of the REIL connected into the circuit. The design engineer needs to ascertain from the regulator manufacturer which type of CCR will handle the overall series circuit load with the addition of the REIL pulse-type load without adverse effect. It has been shown that the problem will be minimized if the REIL are connected into series circuits that have primarily incandescent loads and the circuit load approaches the capacity of the regulator.

15.6.1. The actual regulator capacity needed to operate the REIL properly is much greater than the rated load indicated in the typical product literature. Usually the average power requirement is provided; however, the regulator has to accommodate the instantaneous, or pulsing, load to provide the flashing characteristics of the REIL. That REIL may be rated to require only 400 watts to operate, but may actually require up to 4 kilowatts of regulator capacity to meet the pulsing load requirements when also including the impact of the series circuit adapters between the series circuit and the REIL. The series circuit adapters convert 6.6 amps to 120 volts for REIL operation, and often have low efficiency that imposes higher than expected loads on the regulator. The proper sizing of the regulator requires careful consideration of the types of loads on the circuit and the true impact of those loads on the regulator.

15.6.2. As described in paragraph 15.6.1, the REIL can impose significant loads on the CCR powering the circuits to which they may be connected. It is preferable, if the budget permits, to have separate circuits with 240/120 volt service to power the REILs, thereby eliminating any adverse impacts on series lighting circuits.

15.6.3. Sample calculations and comparison with test data, as well as guidance for setting taps, are shown in figure 15.4. A table format for calculating airfield lighting series circuit loads is shown in table 15.4. Carefully consider the notes in table 15.4. when determining load values.

15.7. Cable. The primary series circuit utilizes FAA L-824 Type C cable, which is XLP (cross-linked polyethylene) insulated 5kV, single conductor, stranded. L-823 connectors are used for connections. For 6.6 ampere primary series AGL circuits, a #8 AWG conductor is normally used. A #6 AWG conductor is used with 20 ampere circuits. For the secondary side lighting loads, a two-conductor #10, 600V insulation is normally used.

15.7.1. The cable is installed in conduit, although it may be direct buried (L-824 cable is rated for direct burial). It is important that insulation is intact and that proper connections are made. Deteriorated or damaged cable can result in current leakage and may present a high voltage hazard to maintenance personnel. While installation in conduit may cost more, this method usually provides longer circuit life, and makes troubleshooting and replacement of cable segments easier.

15.7.2. The types of faults associated with series circuit cable are open circuit conditions and shorts-to-ground. An open circuit condition will turn off all the lights. A single short-to-ground will not impact the lighting, but multiple shorts-to-ground can cause dimming of lights or outages for portions of the circuit or for the entire circuit.

15.8. Transformers. The isolation transformer provides: electrical isolation between the high voltage series circuit and the low voltage secondary feeding the lighting load (such as a fixture or sign), constant current output for a constant current input at the correct ratio, and an effective short circuit in the event of an open condition in the light fixture, for example with lamp filament failure.

15.8.1. With the isolation transformer, only low voltage is brought to the light fixture (via the secondary circuit), and failure of the light does not cause an open condition on the primary circuit that would result in other lights and other connected loads to be shut off.

15.8.2. Isolation transformers for AGL are covered by FAA Specification L-830 (for 60 Hz) and FAA Specification L-831 (for 50 Hz), and are typically 6.6 amperes on the secondary side, with either 6.6 amperes or 20 amperes on the primary side for series lighting circuits at the highest intensity step. The wattage of the isolation transformer is approximately matched to the connected load on the secondary side. Do not operate isolation transformers above their rated wattage.

15.9. Lamps. The connected load typically includes light fixtures, lighted guidance signs, and in some cases other lighted visual aids such as REIL, PAPI, or lighted wind cones.

15.9.1. Runway and taxiway lights may have newer quartz-type lamps or incandescent-type lamps. Quartz-type lamps provide improved photometrics at lower wattage for higher intensity systems, hence lower energy consumption and cost. Many prefer to stay with incandescent lamps for taxiway edge lights, in part because quartz lamps have been found to burn out prematurely, and because for this type fixture there is no reduction in wattage using a quartz type lamp.

15.9.2. Light fixtures basically provide a resistive type load on a series circuit. Some items, such as flashing REIL, or signs using electronics to provide light output within a certain range at all circuit intensity steps,

introduce other reactive type loads into a circuit, which may distort the waveform and have an adverse effect on performance and control. Incandescent lamps have an initial cost lower than quartz lamps.

15.9.3. Current levels have been established such that, for 5-step system, the light output (brightness) is 100%, 20%, 4%, 0.8%, and 0.16%. A system with 3-step control provides light output at 100%, 30% and 10% at the respective brightness steps.

Figure 15.4. Sample Calculation of CCR Test Data.

(1 of 2)

SAMPLE CALCULATIONS, CCR TESTING

DATA: CCR: 30KW, 480V input, 5-step (2.8A - 6.6A)

Cable: #8 AWG, 5kV, L-824 Type C, 20,000 feet primary circuit

Circuit Load: 70 Edge lights @ 120W (100W transformer)

16 Thld/end lights @ 200W (200W transformer)

10 signs @ 100VA (at step 5) }
5 signs @ 200VA (at step 5) } *(at the input to the isolation transformer)*
3 signs @ 300VA (at step 5) }

1 REIL system (2 units) @ 400W, connected by power adapter, with Power Factor of 0.43. [Note that in this example the REIL is adjusted only for PF. Some REIL may require further adjustment, based on manufacturer's information.]

Cable losses (resistance) @25°C: $0.68\Omega/1000'$

Fixture losses (obtain from Mfg - This example assumes 18% for 120W, and 11% for 200W lights)

CALCULATIONS:

1. CCR rated output voltage, $V_{RMS} = 30KW/6.6A = \underline{4,545V}$

2. Total connected load, $KVA = \{ \frac{W_{lamps}}{PF} + \frac{[W_{REIL}]}{1000} + \frac{[VA_{signs}]}{1000} + \frac{Fixture\ losses}{1000} + \frac{Cable\ losses}{1000} \}$

Fixture losses = $(70 \times 120 \times 0.18) + (16 \times 200 \times 0.11) = \underline{1,864W}$

Cable losses = $I^2R = [6.6]^2 \times (0.68 \times 20) = \underline{592W}$

TOTAL KVA = $\frac{(70 \times 120) + (16 \times 200) + (400/0.43) + (10 \times 100 + 5 \times 200 + 3 \times 300) + 592 + 1,864}{1,000}$

= $\underline{17.89\ KVA}$

where:

KVA = kilovolt-amperes V_{RMS} = Rated output voltage of CCR

V = volts W_{lamps} = Wattage of light fixtures

A = amperes W_{REIL} = Wattage of REIL

KW = kilowatts PF = Power Factor

CCR = Constant Current Regulator I = Current, in amperes

R = Resistance in Ohms, Ω

Figure 15.4. Sample Calculation of CCR Test Data (Cont.)

(2 of 2)

SAMPLE CALCULATIONS, CCR TESTING (Cont.)

NOTE: Traditional method (FAA AC 150/5340-24, Figure 6) for determining the load KW assumes that the CCR powers a unity power factor lamp circuit. With REILs, new type signs, and runway guard lights (wig-wags), a unity power factor is not representative, and power factor must be considered.

MEASURED RESULTS (Case 1):

- Output current at Step 5 = 6.52A
- Output voltage at Step 5 = 2,880V

Total KVA Load based on measurements = $6.52\text{A} \times 2.88\text{kV} = 18.8\text{KVA}$

CONCLUSIONS: The output current is within FAA tolerance. The total KVA measured is slightly higher than the calculated load. This may be due to slightly higher actual fixture losses than assumed values. Overall, the CCR is operating satisfactorily.

MEASURED RESULTS (Case 2):

- Output current at Step 5 = 6.52A
- Output voltage at Step 5 = 1,880V

Total KVA Load based on measurements = $6.52\text{A} \times 1.88\text{kV} = 12.3\text{KVA}$

CONCLUSIONS: The output current is within FAA tolerance. The total KVA measured is significantly less than the calculated load. The results suggest a partial shorting of the load.

MEASURED RESULTS (Case 3):

- Output current at Step 5 = 6.30A
- Output voltage at Step 5 = 2,550V

From test results, Total KVA Load = $6.30\text{A} \times 2.55\text{kV} = 16.1\text{KVA}$

CONCLUSIONS: The output current is below that allowed by FAA tolerance. The total KVA measured is below the normal value (2,880V) as found in first test. Results indicate faulty CCR, and a short circuit test should be performed on the CCR.

CCR TAP SETTING:

In above example, it was found that under normal operating conditions (Case 1) the total load is 18.8KVA, or about 63% of the rated 30KW output for the CCR. To achieve minimum distorted sinusoidal wave form where there is a significant harmonic presence (particularly for SCR type CCRs), it is desired to have CCR operate at least at 80% of its rated output. If the CCR is provided with tap setting arrangement (for example 25%, 50%, 75%), then tap the CCR on 75% (at 22.5KW). This will bring the total connected load, as measured, to about 84% of CCR output KW.

NOTE: Analysis compares KVA with KW. This is because the rated output of the CCR is specified in KW in compliance with FAA AC 150/5345-10E. However, load measurements result in KVA. The requirement for total load in KVA to be below the CCR output in KW under operational conditions ensures that the CCR is not overloaded.

15.9.4. FAA-specified types of connected loads that may be used for AGL systems are:

Elevated Light Fixtures

L-860	RW edge, low intensity
L-860E	RW threshold/end, low intensity
L-861	RW edge, medium intensity
L-861SE	RW threshold/end, medium intensity.
L-861E	RW threshold/end, medium intensity (may be used instead of SE for RWs with either REIL, VASI/PAPI or medium approach lighting (MALIS)).
L-862	RW edge, high intensity
L-862E	RW threshold/end, high intensity
L-861T	TW edge
L-804	Runway guard (wig-wag)

In-pavement Light Fixtures

L-850A	RW centerline, high intensity
L-850B	RW touchdown zone, high intensity
L-850C	RW edge, high intensity
L-850D	RW threshold/end, high intensity
L-852A	TW centerline, for straight portion (narrow beam) (non-Category III). Also used for caution bar.
L-852B	TW centerline, for curved portion (wide beam) (non-Category III).
L-852E	TW intersection

Light Bases for Lights or as Junction Boxes.

L-867	Non-load bearing (used in shoulder areas or other non-traffic areas).		
L-868	Load bearing (used in RW and TW pavements and other aircraft load areas).		
Sizes	A - 10" dia. (L-868 only)	C - 15" dia. (L-868 only)	
	B - 12" dia. (L-867 & L-868)	D - 16" dia. (L-867 only)	
L-869	In-pavement junction box (used with cables in saw kerfs, 6" dia.)		

Airfield Signs

L-858Y	Direction, Destination and Boundary. Black legend on yellow background.
L-858R	Mandatory Instruction. White legend on red background.
L-858L	TW and RW Location. Yellow legend and border on black background.
L-858B	Runway Distance Remaining. White legend on black background.

Other Examples

L-849	REIL
L-880	PAPI system with 4 light units
L-881	PAPI system with 2 light units

Some of the above have variations specific for certain military applications. See Chapter 13 for a list of qualifying equipment and specific applications for each type of equipment.

15.10. Parallel Circuits. Parallel (or multiple) circuits have circuit elements connected across the conductors to which input voltage is applied. In theory, the same voltage is applied to each light, although voltage drop occurs along the conductor, which can be significant for longer circuits. The reduced voltage can reduce the intensity of lights at the far end of a circuit. If intensity control is required for this type lighting circuit, tapped transformers or inductive-voltage regulators are used, which increases the cost and reduces efficiency of the circuit.

15.10.1. Advantages of parallel lighting circuits are:

15.10.1.1. Lower cost installation, particularly if voltage regulation and intensity control are not required.

15.10.1.2. More efficient utilization of electrical power.

15.10.1.3. Easy to add to or reduce an existing circuit.

15.10.1.4. Circuits are more familiar to most people.

15.10.1.5. Cable faults such as open-circuits are easier to locate.

15.10.1.6. An open-circuit may not disable entire circuit.

15.10.2. Disadvantages of parallel lighting circuits are:

15.10.2.1. Intensity of lights decreases with line voltage drop along the circuit. This could be misinterpreted if noticeable in a pattern of many lights.

15.10.2.2. Two conductors are required along the complete circuit, and larger conductors may be needed to reduce voltage drop.

15.10.2.3. Lamp filaments are usually longer which may require larger optics and larger light fixtures.

15.10.2.4. Intensity control, particularly at the lower intensity, is more difficult to achieve without added equipment cost.

15.10.2.5. A single ground fault on the high voltage feeder will disable the circuits.

15.10.2.6. Ground faults are difficult to locate.

15.10.3. Parallel circuits are used for most area illumination, individual or small numbers of visual aids, and power distribution. AGL systems typically using parallel circuits are apron floodlighting, other apron lights, sequence-flashing lights, special purpose visual aids such as beacons and wind direction indicators, some obstacle lights, and electrical distribution circuits.

15.11. Current and Voltage on Series Circuits. The output current for AGL constant current series circuits have become standardized at either 6.6 amperes or 20 amperes (at highest intensity). The loaded output voltage from the CCR is limited to 5,000 volts because the cable used for the primary lighting circuit is rated for 5kV.

15.11.1. The voltage will vary depending on the connected load. Figure 15.4 illustrates the constant current and varying voltage through several examples. As seen from figure 15.4, the voltage measured across the outputs of the CCR (at highest intensity step) is simply the total watts divided by 6.6 A (assuming power factor of 1.0), or 3,030V for 200 each 100W lamps (such as light fixtures or signs). With 200W lamps, the voltage is calculated at 6,060V, which exceeds the 5kV cable rating of the primary circuit. However, if a 20A circuit is used, the voltage calculates to be only 2,000V at the CCR. Similarly, if 45W lamps are used in the above example, the voltage across the CCR output terminals is calculated at 1,364V.

15.11.2. The examples above show that the voltage on the primary circuit is additive and will vary with the load, but the current will remain the same. The secondary circuit is always 6.6A (highest intensity step), with a 6.6A/6.6A isolation transformer used with 6.6A primary circuits, and 20A/6.6A isolation transformers used with 20A primary circuits.

15.11.3. Figure 15.5 shows that measuring the voltage across the secondary circuit for a 100W light fixture will yield 15.15V. Similarly, the voltage will be 30.3V with a 200W light, and only 6.8V with a 45W light.

5.11.3.1. The current is constant regardless of load (within limits), while the voltage is additive and will vary with load.

Diagram illustrating a lighting circuit configuration for voltage calculations. The circuit includes a CCR (Circuit Control Relay) connected to a HOMERUN (to first fixture). The circuit is labeled with various components and calculations:

- 6.6A primary
- 6.6A on Secondary
- 100W lamp
- Jumper
- HOMERUN (to first fixture)

Examples of voltage calculations are provided at the bottom:

EXAMPLES OF VOLTAGE CALCULATIONS

ASSUMPTIONS

- 200 lights on 6.6A primary series circuit
- Each light 100W (fixture or sign, etc)
- Power factor of 1.0 for all components.

1. Measured across homeruns at CCR, (1) & (2) voltage = $\frac{200\text{ea} \times 100\text{W}}{6.6\text{A}} = 3,030\text{V}$
If only 100 lights, then voltage is 1,515V
2. Measured across isolation transformer primary (3) & (4) or secondary (3') & (4')
Voltage = $\frac{100\text{W}}{6.6\text{A}} = 15.15\text{V}$
With 200W light, voltage on secondary = $\frac{200\text{W}}{6.6\text{A}} = 30.3\text{V}$
With 200W lamps, voltage at CCR = $\frac{200\text{ea} \times 200\text{W}}{6.6\text{A}} = 6,060\text{V}$
3. With 200W lamps and a 20A primary, voltage at CCR = $\frac{200\text{ea} \times 200\text{W}}{20\text{A}} = 2,000\text{V}$
4. If jumper across at light fixtures (5) & (6), the voltage at CCR is based on load remaining on circuit.
5. If 85 each 200W lights remain on 6.6A circuit: Voltage = $\frac{85\text{ea} \times 200\text{W}}{6.6\text{A}} = 2,576\text{V}$

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15.11.3.2. The low voltage on the secondary side is isolated from the high voltage primary side by the isolation transformer.

15.11.4. When more than one light is connected to a secondary circuit, they are connected in series. An isolation transformer is designed to provide a proper variable operating voltage on its secondary. This forces a constant load current to flow so that each light in the secondary will receive the same current regardless of the wattage of the lamp or the quantity of lamps (within the design limits of the transformer). This approach may be seen on light bars for approach lighting systems, on runway centerline lights configured as smaller segments with several lights on a single transformer, and other applications.

15.11.5. It is important to recognize that the current transformer operates differently than the standard voltage transformer. The current will remain constant even when the secondary side is shorted. The output terminals of the CCR are not grounded, hence the airfield lighting series circuit is an ungrounded system. The result is that one short-to-ground in the primary circuit will not shut down the system. When the secondary side is open (for example a burned out lamp), the instantaneous voltage present at the lamp socket can be very high, presenting a potential hazard for maintenance personnel. This can be the condition when changing lamps and a short occurs between the socket terminals and the body of the light fixture.

15.12. Selection of 6.6 versus 20 Amperes System. As noted above, the most common constant current regulator outputs used to power the primary series circuits for runway, taxiway, and approach light systems at airfields and heliports are 6.6 amperes (6.6A) and 20 amperes (20A). A 6.6A circuit may operate on three or five different intensity levels. A 20A circuits typically operates only as a five intensity level system, although it can be used on circuits which operate on three intensity levels, provided that the three levels are the same as used on the 6.6 amp system (4.8A, 5.5A and 6.6A), as measured on the secondary side of the isolation transformer. Nevertheless, the two systems have somewhat different characteristics and the preference for one or the other depends on the specific operational application and the geometric configuration of the airfield lighting circuits. To determine the preferred system for a particular design application, it is necessary to evaluate the system characteristics of each system from the standpoint of safety, reliability and economics.

15.12.1. The 6.6A primary series circuit generally consists of No. 8AWG 5kV non-shielded cable, connected in series with isolation transformers having a 1:1 operating ratio. This provides 6.6A on the secondary to the lighting component from 6.6A on the primary side. The 20A primary series circuit consists of No. 6AWG 5kV non-shielded cable, connected in series with isolation transformers having an operating ratio of about 3:1. This provides 6.6A on the secondary to the lighting component from 20A on the primary side.

15.12.2. Based on the standard 5kV rating of the primary cable, it can be seen that the 6.6A system can be powered by a regulator with a rated capacity of not more than 30KW. ($30\text{KW} / 6.6\text{A} = 4545 \text{ volts}$) The 20A system can be powered by a regulator with a rated capacity of 70KW, the largest regulator currently manufactured, without constraints ($70\text{KW} / 20\text{A} = 3500 \text{ volts}$). Cable losses ($\text{amperes}^2 \times \text{cable conductor resistance}$) for the cable typically used in a 20A system will be as much as four times higher than those for the cable used in a 6.6A system (approximately 164 watts/1000 feet compared with 37 watts/1000 feet).

15.12.3. For a given load, the regulator output voltage for the 6.6A system will be more than 3 times higher than the output voltage for a 20A system. In the example above for a 30KW load, the output voltage for a 6.6A system is about 4545V. For the same load on a 20A system, the voltage is only 1500V. The stress on the primary cable insulation as well as the cable connectors will be greater when the voltage is higher, resulting in earlier cable deterioration and greater susceptibility to failure. With voltages above 2400V, the electric field may not be entirely confined within the cable insulation when unshielded cable is used. This can lead to potential problems such as surface discharge and surface cracking at terminations. Such surface discharge and

cracking can lead to further deterioration and possible cable failure. These problems are particularly likely to arise when the cable is installed in wet or contaminated locations.

15.12.4. It is recognized that most of the system operation, whether 6.6 or 20 amps, is not usually at the highest intensity level, thus not at highest loading. Most systems are typically operated at mid-level intensities (level 2 for 3-step systems or level 3 for 5-step systems - about 4.1A). Thus, a 5-step circuit with a load of 25KW at full intensity will only be loaded to about 9.6KW at intensity step 3. At 9.6KW output at 4.1A, only 2353V is imposed on the primary cable, well below the rated capacity.

15.12.5. Cost Comparison. No. 6 AWG cable is more expensive than No. 8 AWG. The 20A:6.6A isolation transformer is more expensive than the 6.6A:6.6A isolation transformer. The 20A output regulator is slightly more expensive than the 6.6A output regulator. Therefore, the cost of a 20A system for any particular circuit will be greater than the cost of a 6.6A system for that circuit. Proper consideration of actual operating requirements in the design may show that a 30KW regulator with a 6.6A output will provide 25KW, which will be sufficient to power a circuit up to 2,440 meters (8000 feet) with runway centerline lights, edge lights, or touchdown zone lights. However, if more than one 6.6A circuit is required to power a particular airfield lighting system, for example, a 3,660 meter (12,000 foot) runway edge lighting system, two or three 6.6A systems would be required, which would have higher initial cost than a single 20A system. Cost should, however, be considered over the operating life of a system. One factor is the energy costs, which would generally be higher for the 20A system than for the 6.6A system.

15.12.6. Conclusion. It is clear that there is no simple process for the selection of which system to use in any particular case. No compromises should be made when it comes to safety. However, the designer needs to consider the operational requirements of the airbase and the airfield lighting systems, the geometrical layout of the proposed circuits, and the soil conditions for the cable installations. The economic evaluation should include installation costs, operating costs, and life expectancy.

15.13. Considerations for Circuit Design. Two major considerations in designing an airfield lighting series circuit are: maximum allowable voltage on the primary series cable (discussed in paragraph 15.12 in the selection of 6.6A or 20A circuit); and the insulation resistance of the entire primary circuit.

15.13.1. Insulation Resistance. FAA has established a minimum insulation resistance of 50 megohms for new installations. Experience from many projects has shown that this value is achievable. However, insulation resistance depends on the length of the primary series cable, the number of splices on the circuit, soil conditions, and primarily the number of isolation transformers of the circuit. The designer should therefore consider all these factors in configuring a lighting circuit.

15.13.2. From the standpoint of economy, life expectancy and reliability, it may be practical to use 50 megohms as the minimum insulation resistance for. The selected value depends on the specific configuration of the particular system being designed. It is recommended the following criteria be applied in optimizing design of new airfield lighting circuits:

15.13.2.1. Limit the voltage to 2400 volts, at least for 90% of the operational time.

15.13.2.2. Limit the number of isolation transformers on any one primary circuit to not more than 130.

15.13.2.3. Limit the number of splices on any one primary circuit (not including those connecting isolation transformers) to not more than 8.

15.14. Circuit Configuration. There are three circuit configurations that are normally used to power runway and taxiway systems:

15.14.1. Single Circuit per Lighting System. This is the standard FAA configuration, with a single circuit for each of the different lighting systems (for example, one circuit for the runway edge lights, one for the

touchdown zone lights, or one for the runway centerline lights). It is the most economical configuration. In some cases, however, this approach may create very high voltages on the primary series circuit, which can reduce the life and reliability of the system and increase the potential hazards for maintenance personnel. In addition, in the event of a fault in the circuit, the entire circuit is out of service. Also, the trouble-shooting of line faults can be a lengthy, time consuming process because of the length of the circuit.

15.14.2. Multiple Circuits per Lighting System - Split Circuits. Advantages include easier troubleshooting and reduction in circuit voltages. A disadvantage with this configuration is the higher cost compared with a single circuit, particularly if the available space in the vault or the duct system is limited. The designer should also consider the possible consequences of a partial system failure. For example, where two circuits power a runway edge lighting system, the failure of one circuit leaves the other circuit to light only half the runway, indicating a much shorter available runway to the pilot. It may be necessary to install an interlock between the regulators so that both circuits will shut down if either circuit fails.

15.14.3. Multiple Circuits per Lighting System - Interleaved Circuits. This is the type of circuit configuration specified by ICAO. Although this is the most expensive configuration, requiring more cable, it has the advantage of preserving the full pattern of the airfield lighting system for the pilots in the event of one circuit failure, hence provides a measure of additional operational safety. Further, it has the advantages noted for the split circuit configuration.

15.15. Parallel Circuits. Parallel (or multiple) circuits have circuit elements connected across the conductors to which input voltage is applied. In theory, the same voltage is applied to each light, although voltage drop occurs along the conductor, which can be significant for longer circuits. The reduced voltage can reduce the intensity of lights at the far end of a circuit. If intensity control is required for this type lighting circuit, tapped transformers or inductive-voltage regulators are used, which increases the cost and reduces efficiency of the circuit.

15.16. Photometric Characteristics of Light Fixtures.

15.16.1. Airfield lighting provides visible light to pilots for guidance during landing and taxiing operations. The guidance provided is a function of configuration of the lights, light color, and strength and “shape” of the light output (photometric performance). The strength is the brightness or intensity of the light output, measured in candelas. The required shape of the light “beam” from a light fixture is typically represented by an ellipse (an “isocandela curve” of same values), although for some fixtures the requirements may be rectangular or simply numerical. Examples are shown in figure 4.2 (high intensity white or “clear” runway edge light) and figure 4.5 (high intensity green threshold light), which illustrate the photometric requirements at highest intensity step for the type of light.

15.16.2. The wattage of lamp(s) and other light fixture characteristics are determined by each manufacturer in order to meet the photometric requirements for a particular type of light, which are tested and certified for compliance with the requirements. A light fixture design is based on achieving the required photometric output at full rated lamp wattages, in fixtures connected on a 6.6 amperes series lighting circuit. The lower current steps of series lighting circuits are based on achieving lower levels of light output.

15.16.3. Figure 15.6 shows a typical photometric requirements or “isocandela curves” for a runway edge light. The ellipses are defined by degree of angle from the center along vertical and horizontal axes. The requirements for the inner ellipse, or “main beam,” are:

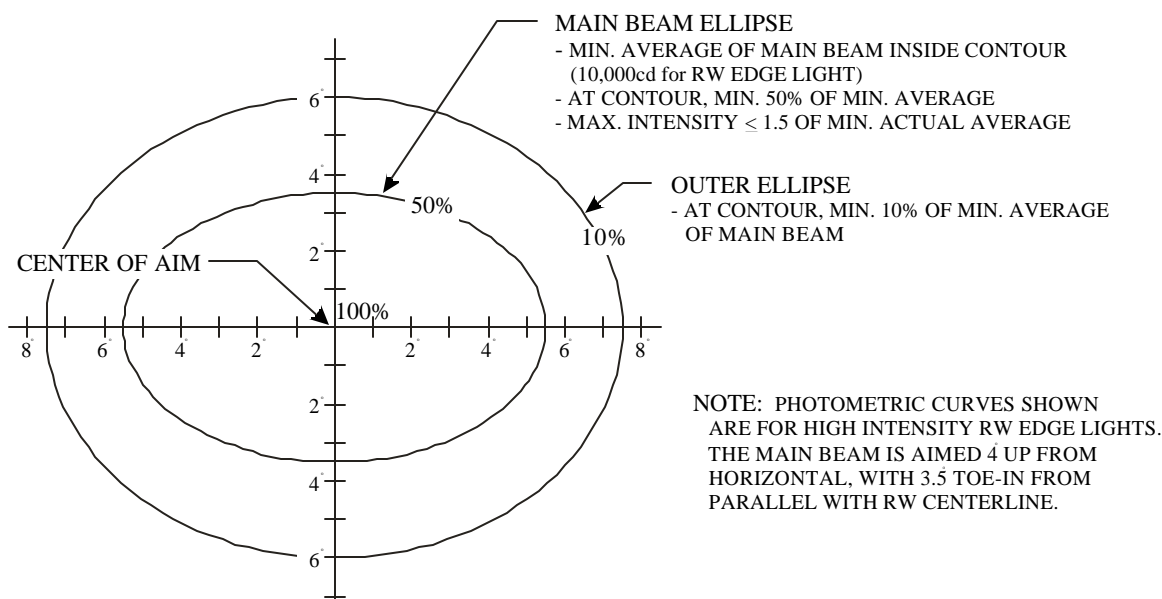
15.16.3.1. Minimum average intensity (10,000 cd, aviation white in the example).

15.16.3.2. Minimum intensity no less than 50% of the minimum average intensity (5,000 cd in this case).

15.16.3.3. Maximum intensity should not exceed 1.5 times the actual average intensity.

For the outer ellipse, the minimum intensity should not be less than 10% of the minimum average intensity (1,000 cd in the example).

Figure 15.6. Photometric Isocandela Curves.



15.16.4. For the example shown by Figure 15.6 (high intensity runway edge light for runways less than 60 meters (200 feet) wide), the inner or main beam ellipse is defined by ± 5.5 degrees on the horizontal axis and ± 3.5 degrees and -3.5 degrees on the vertical axis, while the outer ellipse is defined by ± 7.5 degrees on the horizontal axis and ± 6 degrees on the vertical axis. Note that in Figure 4.2, the runway edge lights have a wider beam ellipse for runways 60 meters (200 feet) or more wide, providing broader light coverage. The runway edge lights are “toed-in” 3.5 degrees and aimed up 4 degrees above the horizontal. Threshold lights are parallel with the runway centerline and aimed up 4.5 degrees. Other lights may also have a toe-in or aimed vertically upward; however, this is identified separately and not indicated on the photometric curves.

15.16.5. Photometric Testing of New Lighting Systems. Photometric testing of new airfield lighting installations is being performed more and more as a part of the acceptance testing of the overall system, and includes the evaluation of a variety of factors in the lighting system being tested. While field testing the photometrics of installed lights has not been practical in the past, current available technology enables the testing of an entire system in a relatively short period of time, testing each fixture, with good correlation to laboratory testing for meeting photometric requirements. In addition to verifying the photometric performance of installed light fixtures, proper testing can also help identify the following:

- 15.16.5.1. Possible leakage on the secondary side of the isolation transformer.
- 15.16.5.2. Improper alignment of fixtures.
- 15.16.5.3. Loose sockets and brackets.
- 15.16.5.4. If improper lamps have been installed.
- 15.16.5.5. Possible damage to lenses from sandblasting or other source of abrasion.
- 15.16.5.6. Improper current output from the constant current regulator.
- 15.16.5.7. These types of deficiencies may cause significant reductions in the photometric output of a fixture, as well as the quality of the overall system performance. The cost of photometric testing is relatively

inexpensive compared with the cost of a new airfield lighting system, while providing assurances for operational safety. The testing can usually be performed with minimal disruption to airfield operations, and is typically performed at night during periods of low or no aircraft traffic.

15.16.6. Photometric Testing of Existing Lighting Systems. This can provide benefits similar to acceptance testing of new lighting systems. Typically, photometric performance deteriorates over time, and periodic testing will provide an up-to-date evaluation of performance. When photometric output is found to be below 50% to 70% of the minimum specified output, investigation should be made as to possible cause and corrective action, whether by replacement or repair. Test results enable the airfield to repair/replace fixtures on a “need” basis rather than scheduled basis, with possible cost savings plus the assurance that the lighting system is providing the proper light output.

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Attachment 1

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Abbreviations and Acronyms

AC—Advisory Circular

AGL—Airfield Ground Lighting

AGM—Arresting Gear Marker

AIR STD—Air Standard

ALS—Approach Landing System

ALSF—Approach Lighting System with Sequence Flashing Lights

ALSF-1—Approach Lighting System with Sequence Flashing Lights for Category I

ALSF-2—Approach Lighting System with Sequence Flashing Lights for Category II or Category III

AMC—Air Mobility Command

ANSI—American National Standards Institute

ASCC—Air Standardization Coordinating Committee

ASTM—American Society for Testing and Materials

AT&A—Air Traffic and Airspace

AWG—American Wire Gauge

CANLS—Contingency Airfield Night Lighting System

CCR—Constant Current Regulator

CD—Candela

CHAPI—Chase Helicopter Approach Path Indicator

EALS—Emergency Airfield Lighting Systems

E/G—Engine Generator
EIA—Electronic Industries Association
EM—Engineer Manual
EMT—Electrical Metal Tubing
FAA—Federal Aviation Administration
FAR—Federal Aviation Regulation
FC—Footcandle
GPS—Global Positioning System
HIRL—High Intensity Runway Edge Lights
ICAO—International Civil Aviation Organization
IEEE—Institute of Electrical and Electronics Engineers
IFR—Instrument Flight Rules
ILS—Instrument Landing System
IMC—Instrument Meteorological Conditions
ISO—International Standards Organization
LIR—Low Impact Resistant
MACOM—Major Command (Army)
MAJCOM—Major Command (Air Force)
MALSR—Medium Intensity Approach Light System with Runway Alignment Indicators
MAS—Military Agency for Standardization
MLS—Microwave Landing System
MIRL—Medium Intensity Runway Edge Lights
MTBF—Mean-Time-Between-Failure
MUTCD—Manual of Uniform Traffic Control Devices (Air Force use AFPAM 32-1097, *Sign Standards Pamphlet*)
NATO—North Atlantic Treaty Organization
NAVAID—Navigational Aid
NEC—National Electrical Code (NFPA 70)
NEMA—National Electrical Manufacturers' Association
ODALS—Omnidirectional Approach Lighting System
OFZ—Obstacle Free Zone
PAPI—Precision Approach Path Indicator
PAR—Precision Approach Radar
PLASI—Pulsed Light Approach Slope Indicator
PLC—Programmable Logic Controllers
RAIL—Runway Alignment Indicator Lights
RCL—Runway Centerline Lights
RDM—Runway Distance Markers
REIL—Runway End Identifier Lights
RGL—Runway Guard Lights
RMS—Root Mean Squared
RPI—Runway Point of Intercept
RPM—Revolutions Per Minute
RRP—Runway Reference Point
RVR—Runway Visual Range

SALS—Short Approach Light System
SAMS—Sign and Marking Supplements
SCR—Silicon Controlled Rectifier
SFL—Sequenced Flashing Lights
SSALR—Simplified Short Approach Light System with Runway Alignment Indicator Lights
STANAG—Standardization Agreement
TACAN—Tactical Air Navigation
TCH—Threshold Crossing Height
TDZL—Touchdown Zone Lights
TERPS—Terminal Instrument Procedures
UL—Underwriter’s Laboratory
USAASA—US Army Aeronautical Service Agency
UPS—Uninterruptible Power Supply
VFR—Visual Flight Rules
VLA—Visual Landing Aids
VMC—Visual Meteorological Conditions

Terms

Approach Light Plane—An imaginary plane that passes through the beam centers of the lights in the system. The plane is rectangular, centered on the ALS centerline, starting at the landing threshold and extending 60 meters (200 feet) beyond the last light at the approach end of system. The plane may have irregularities. The width varies according to the lighting system.

Decision Height—The height above the highest elevation in the touchdown zone, specified for a glide slope approach at which a missed approach procedure must be initiated if the required reference has not been established.

Displaced Threshold Area—An area of full strength pavement on the approach slope of the threshold intended for use during takeoff or during rollout after landing from the opposite direction.

Footcandle—One lumen per square foot (10.8 lux).

Frangible Support—A support for elevated fixtures or other devices composed of a supporting element with a fracture mechanism at its base. It is designed to present a minimum of mass and to break at the base when impacted.

Instrument Runway—A runway served by non-visual aids giving directional guidance adequate for a straight in approach. It may be further classified as:

Precision Approach Runway, Category I—A runway served by an Instrument Landing System (ILS), Microwave Landing System (MLS), or precision Approach Radar (PAR) and visual aids intend for operations down to 60 meters (200 feet) decision height, and down to a runway visual range (RVR) on the order of 720 meters (2,400 feet). These criteria also apply to visual lighting aids supporting Air Force

precision approach radar approaches down to a decision height of 30 meters (100 feet) and an RVR on the order of 360 meters (1,200 feet).

Precision Approach Runway, Category II—A runway served by ILS or MLS and visual aids intended for operations down to 30 meters (100 feet) decision height and down to an RVR on the order of 360 meters (1,200 feet).

Precision Approach Runway, Category III—A runway served by ILS or MLS (no decision height being applicable) and:

Category IIIa: By visual aids intended for operations down to an RVR on the order of 210 meters (700 feet).

Category IIIb: By visual aids intended for operations down to an RVR on the order of 45 meters (150 feet).

Category IIIc: Intended for operations without reliance on external visual reference. (The RVR is 0).

Light Bar—A set of lights arranged in a row perpendicular to the light system centerline, also known as a barrette.

Lux—One lumen per square meter (1/10 (0.0929)) footcandle).

Overrun—An area on the approach side of the runway threshold which is stabilized or paved but is not intended for normal operational use. It serves as a safety area for aircraft which overrun the end of the runway or touch down short of the threshold.

Positive Slope—A slope of the approach light plane upward and outward from the landing threshold.

Rigid Support—A support for elevated lights or other devices which has been designed to support the lights under all foreseeable weather conditions without regard for impact resistance. Do not use these supports in new construction for systems in safety clearance zones or where there is present danger of impact by aircraft.

Runway Centerline—A line halfway between the edges of the surface designated for normal aircraft landing and takeoff operations.

Runway Edge—The sides of a runway designated as full strength and capable of supporting aircraft wheel loads; any area beyond that point is a non-operational area.

Runway End—The longitudinal limit of usable runway opposite the runway threshold. It often, but not always, coincides with the threshold of the opposite direction runway surface.

Runway Visual Range (RVR)—The maximum distance in the direction of take-off or landing from which the runway (or the specified lights or markers delineating it) can be seen from a position above a specified point on the runway centerline and at a height corresponding to the average eye level of pilots at touchdown.

Semi-frangible Support—A two element support for light fixtures or other devices designed for use in applications where the mounting is over 12 meters (40 feet) above the ground and exceeds the design limits for low impact resistant supports mounted on a rigid support and a means to lower the lights for servicing.